VESTIGES
OF THE
MOLTEN GLOBE

W. L. GREEN

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OF

THE MOLTEN GLOBE,

AS EXHIBITED IN

THE FIGURE OF THE EARTH, VOLCANIC ACTION AND PHYSIOGRAPHY.

BY

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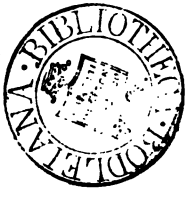
IN THREE PARTS.



LONDON:
EDWARD STANFORD, 55, CHARING CROSS.
1875.

PREFACE.

In 1857, 'The Edinburgh New Philosophical Journal' contained a paper in which I suggested the view that the pyramidal form of the outline of the southern extremities of the continents of the globe was the result of the conical superficial figure of the reliefs of the land entering the ocean at an angle to the spheroidal surface of the sea. That the solid crust of the southern hemisphere in middle latitudes appeared to dip southward under the ocean, and that the pyramidal or triangular extremities of the continents pointing south were the necessary result of that southerly dip, and, by way of illustration, I showed that by slightly arching a card, or by bending it with a ridge along the middle, or on one side, or with one on each side, and holding it with the edges just at the surface of the water, and then depressing one end slightly beneath it, the form of the outline of the different continents and peninsulas could be approximately represented by the card on the water line. I also gave a diagram of an ideal section or plane passing through the earth at the Tropic of Capricorn, and showed that a section taken through any parallel of latitude between the equator and perhaps 60° south, would present approximately on the surface line of the solid crust an hexagonal figure in which each alternate angle is interior compared with the circumscribed circle, and I appealed to mathematicians to inquire whether that was not the form which on mechanical principles should exist on the supposition of the solid crust of the globe collapsing by gravity on to a contracting fluid interior. I also, in the same paper, suggested that such a figure (with the crust in segments) as well as the phenomena of the Hawaiian volcanoes, indicated that the great rises

and falls of molten matter in the rents of the crust of the earth which are open to the surface, as may be assumed to be the case in the volcanoes of Mauna Loa on Hawaii, may be looked upon as simply as the varying height of a column of liquid matter connected with the liquid interior, depending on the pressure or weight of the nearest segments of the earth's crust floating on the fluid nucleus, modified by the temperature and consequent relative liquidity, specific gravity, or height of the molten matter in the conduits.

These views of the form of continents, the figure of the earth, and the nature of volcanic action, then merely touched upon, I propose now to follow up to a more definite conclusion, and to correlate with the associated phenomena.

I feel sensible of the difficulties connected with the subject, and recognize the weight of those authorities who contend that the hypothesis of a *present* thin crust and molten interior of our earth is untenable, whilst the facts which I have now to present seem to indicate precisely that condition of our globe. I must ask therefore from the scientific world, as well as from the reading public, who often give the more just verdict on a first presentation of new views, or, as in this case, of old ones in a new light, an indulgent consideration of the following pages.

I have the less hesitation in treating these somewhat involved phenomena in a popular manner and without the aid of mathematical analysis, because it may be that a patient but practical application of well-known physical principles to dynamical geology may, in the present state of our knowledge, be as useful as the more scientific method of treatment; especially as our mathematicians seem often to be more familiar with powerful analytical methods, than with the facts and circumstances to which those methods have to be applied in the problems before us; and, as Professor Huxley has reminded us, although mathematics is a powerful engine—"a mill that will grind to any degree of fineness"—"what we get out depends upon what we put in," and that "we cannot expect to get fine flour from peascods." I am desirous, therefore, in this inquiry of performing the office of a carrier of grist to the mathematical mill rather

than of presenting final solutions of the many intricate questions involved. It is by the application of the elementary principles of physics to the more prominent features of the earth's surface, as well as to volcanic action, in their obvious connection with the theory of a molten nucleus, that I hope to illustrate the inquiry. Only the imperfection of the ideas or of the language in which they are conveyed can prevent the following pages being intelligible to every reader. I have endeavoured to be both definite and concise, so that where the facts or views are mistaken they may be the more easily refuted: for although it has been said on high authority that a bad hypothesis is better than none, a plausible theory of the earth and volcanic action, if not well founded, may retard rather than hasten what is so much to be desired, the true and complete solution of the problem of the cooling globe.

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VESTIGES OF THE MOLTEN GLOBE.

PART I.—THE FIGURE OF THE EARTH, AND GENESIS OF THE CONTINENTS.

CHAPTER I.

General comparison between the figure of the solid crust of the earth and the crystal the six-faced tetrahedron with convex faces.

SINCE the date of the great maritime discoveries which followed the bold lead of Columbus, physical geographers have been gazing at the startling peculiarity of the configuration of the land of our globe, namely, that it all points southward in great pyramidal masses; a few conjectures have been hazarded to account for the facts, but no attempt worthy of the name has been made to interpret the meaning of a phenomenon as remarkable as it is world-wide. Had we noticed the repetition of regular and definite figures, such as the coast lines of our earth present, in Mars or Venus, we should probably have endeavoured to comprehend them; whilst being close at hand they have failed to arrest adequate attention, and even the scientific world seems still to contemplate them as the American Indian regards the locomotive or the telegraph wire, with a dignified toleration of what is apparently inexplicable. But as the patient study of half-defaced hieroglyphics reveals to us the early records of some of our race, surely those grand characters which stand out so prominently on the face of our planet may be compelled by similar means to relate their own history.

The great French geometrician and geologist, Elie de Beau-

mont, has long contended that the grand lines of dislocation and upheaval on the surface of our globe indicate a relation between those lines and the corresponding edges of some geometrical solid; and although our countryman, Hopkins,* showed with an almost too severe reasoning that Beaumont's favourite *réseau pentagonal*, or five-sided net, could not be applied to a terrestrial globe so as to include and correspond with the great physical features of our earth, no one seemed to regret more than Hopkins that the details of the ingenious and laboriously worked out hypothesis of the French geometer would not stand the test of a rigorous analysis; whilst at the same time his views evidently comprehended grand truths. If we are at length enabled to indicate the geometrical solid or crystal which being so applied will include and correspond with the physical facts of the earth's surface, it is because Beaumont first suggested the idea and pointed out how the figure was to be sought. The form is included in his *réseau triangulaire*, and is, as I propose to show, the six-faced tetrahedron; the easterly sag or twist of the crust of the Southern Hemisphere on a twin plane, the apparently macled form of the crystal, having caused the lines of relief and depression of the earth's surface to elude solution, whilst the *réseau* of that crystal in its simple form alone was applied to them.

It will seem at first glance somewhat far fetched to compare our apparently slightly compressed spheroidal globe with so four-cornered an object as the model of a six-faced tetrahedron such as is usually constructed for the purpose of illustration. That construction, however, is much the best, in a preliminary view of the subject, by which to show broadly but distinctly the general figure of the solid crust of our earth, and to enable us to understand and readily appreciate how far the two figures agree or differ. Crystallographers are aware that the six-faced tetrahedron with convex faces may geometrically, as well as in nature and fact, approach the form of a sphere, and that many diamonds possessing that crystalline figure are hardly distin-

* See Anniversary Address of the President of the Geological Society of London, February, 1853.

guishable from spheres, but yet may be true six-faced tetrahedrons.

If, then, we take in the hand an ordinary model of a six-faced tetrahedron (not macled, and even without convex faces), constructed of wood, or such as can be readily constructed with cardboard and a little glue, and run a wire or needle through any one of the tetrahedral, or as they are also called the octohedral axes, that is, the axes joining the four acute six-faced solid angles with the opposite obtuse six-faced solid angles, and contemplate that pole of this axis which is at the obtuse solid angle, as the North Pole of our earth, the needle or wire then indicating the axis of rotation, we are enabled to represent to ourselves, in a general view on the model, the whole of the main features of the globe. This will be elucidated more in detail and by maps in the sequel; but to assist in obtaining a clear general idea of what is designed to be explained, the model crystal with the wire axis may be studied with advantage, always bearing in mind, however, how closely a six-faced tetrahedron with convex faces may approach to a sphere or to a spheroid.

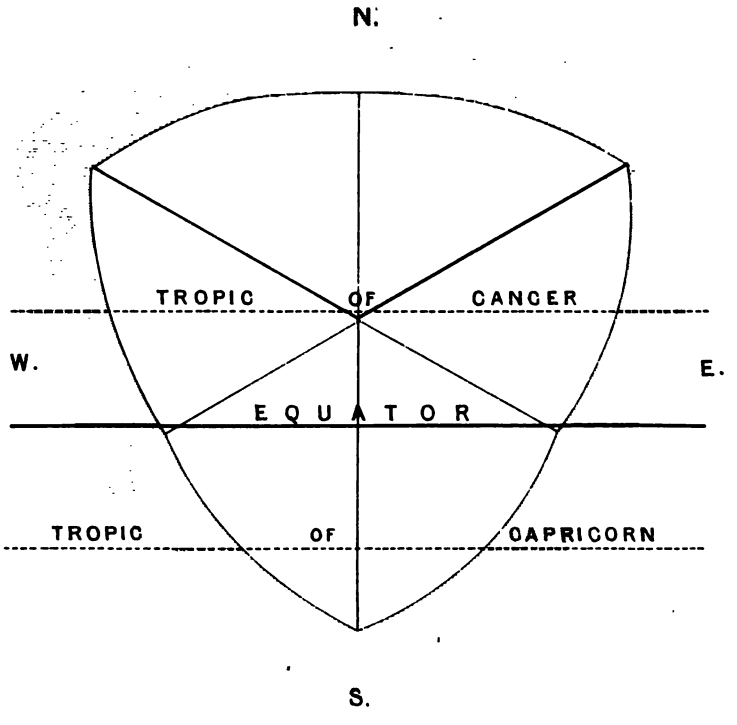
Let the North Pole (at the obtuse solid angle of the wire axis) be held uppermost, to agree with our usual ideas of contemplating the earth. Now let us first conceive the surface of the model crystal to be the *solid* crust of our earth without any ocean; then let us imagine what would be the effect of introducing such a quantity of water on to the model as would cover about three parts out of four of its surface, that is, in about the proportion of water to land on the earth, and supposing that the model attracts the water to its centre of gravity as the earth does, but omitting from our consideration for the present, for the sake of simplicity, the effect the centrifugal force caused by the rotation of the crystal on its axis would have upon the form which the surface of the water would assume, as well as the slight flattening over the obtuse angles, and the heaping up of the water towards the acute angles. What portions of our model crystal would under such circumstances necessarily project above the surface of the liquid? It becomes evident by inspection of the model, as well as demonstrable by natural laws, that the four

corners, or, in technical language, the four acute six-faced solid angles would alone project like large islands of equal size and shape above the surface, leaving four large equal and similar water spaces all connected with each other over the remaining three fourths of the surface. Conceiving, then, our model thus much covered by water, with the four acute solid angles alone projecting above the surface, we obtain a general view of the facts as they exist on the surface of our earth to the following extent. We have before us the four great continents and the four great oceans of the physical geographer—that is to say, the three double continents,* Europe—Africa, North—South America, Asia—Australia,† and the Antarctic continent, all represented on the model crystal approximately in their actual relative position on the earth. The water space at the North Pole of the crystal—an *obtuse* solid angle—represents the Polar Basin and Arctic Ocean. Now assume any one of the three lateral projections on the model (that is, any one of the three lateral *acute* six-faced solid angles) to be any one of the three great double continents. We have then, let us say, opposite to us, solid angle No. 1 to represent Europe—Africa (but without the dividing depression of the Mediterranean). Then turning the model to the right, we have

* "Steffens pushed the study of these analogies of the structure of continents further still, and the picture which he gives of them opens several new views of the subject. . . . . Passing to the grouping of the continents among themselves, this learned man brings to our view the fact that these great terrestrial masses are grouped two by two, in three double worlds, of which the two component parts are united together by an isthmus or by a chain of islands; moreover, on one side of the isthmus is found an archipelago, on the opposite side a peninsula."—'Earth and Man,' by Arnold Guyst, late Professor of Physical Geography and History, at Neufchatel, Switzerland. Boston. 1855. Page 82.

† There are two anomalies in the so-called double continent Asia—Australia. It is not separated (in an east and west direction) as the other two double continents are, by an ocean; say at the Aralo-Caspian depression; whilst it is also unlike the other two, just separated (in a north and south direction) at the Eastern Archipelago. The reader may be reminded here that although the ocean is used as an indicator of where the grand reliefs and depressions of the earth's solid crust are, it is of small importance whether a certain portion of the surface be a few feet above or a few feet below the water level, in view of the fact that the differences in the main reliefs and depressions are to be reckoned by miles.

FIGURE 1.



before us a water space or *obtuse* solid angle to represent the Atlantic Ocean. Still turning the crystal, appears the *acute* solid angle (No. 2) representing North—South America (but again without the dividing depression at the Caribbean Sea and Gulf of Mexico); next appears an *obtuse* solid angle or water space to represent the Pacific Ocean; after which appears another *acute* solid angle (No. 3) to represent Asia—Australia (but again without the dividing depression at the Eastern Archipelago). Lastly, an *obtuse* solid angle or water space appears, to represent the Indian Ocean, but spreading itself northward on the model over what is the low Aralo-Caspian depression on the earth. This exhausts all the oceanic water of the globe, and all the continental land except the Antarctic continent, which is, however, represented on the model crystal in its true position by acute solid angle No. 4 at the South Pole.

Thus a general view of the crystal, the six-faced tetrahedron, supposed to be three fourths covered by water attracted towards the centre of gravity of the figure, represents generally all the continents and oceans on the globe in their actual relative positions. As there are four *acute* solid angles on the crystals, so there are four and only four continents or masses in relief on the globe; and as there are four *obtuse* solid angles on the crystal, so there are four and only four grand depressions or oceans on the globe.

Some geographers describe five oceans, adding the Antarctic Ocean to the Atlantic, Indian, Pacific, and Arctic. The discoveries of Ross, Wilkes, and others, in those regions prove however, as Sir Charles Lyell has on other and independent grounds deduced, that there is a continent around the South Pole, not an ocean, and that there is no room for an ocean in the Antarctic regions, as will be more fully explained in the sequel.

The form of the outline or the water line of the four acute six-faced solid angles, which we have supposed to project out of the water on the model crystal, would be similar in each of them, and would appear on a crystal with convex faces as represented in Fig. 1.

This figure represents the normal form of a continent in its

simplest development, namely, as a regular trilobed mass.* The more acute solid edges of the crystal, or those which are farthest from the centre of gravity, indicate comparative relief, and are coloured red, and the more obtuse or relatively depressed solid edges are coloured blue, and this distinction will be preserved throughout.

The form of the outline of the water spaces on each of the four sides or four obtuse solid angles of the model crystal, being bounded by the outline of two faces of each of the three surrounding projecting solid angles, would appear as in Fig. 2. This figure represents the normal form of an ocean as outlined by the normal form of the water line of three surrounding acute solid angles (or continents). It will be observed that in this figure six blue lines, representing the relatively depressed or obtuse solid edges of the crystal, converge to the centre. The close resemblance of this water space on a crystal to the figures of the borders of the Pacific and Indian Oceans is evident.†

Referring again to the model crystal, on which may be sketched the form of the water line of the projecting acute solid angles or normal continents, and revolving it on its axis of rotation, and viewing it as a rough blocked model of the earth, we perceive the reason why the salient features of the surface of our globe exist as they do. We perceive by inspection:

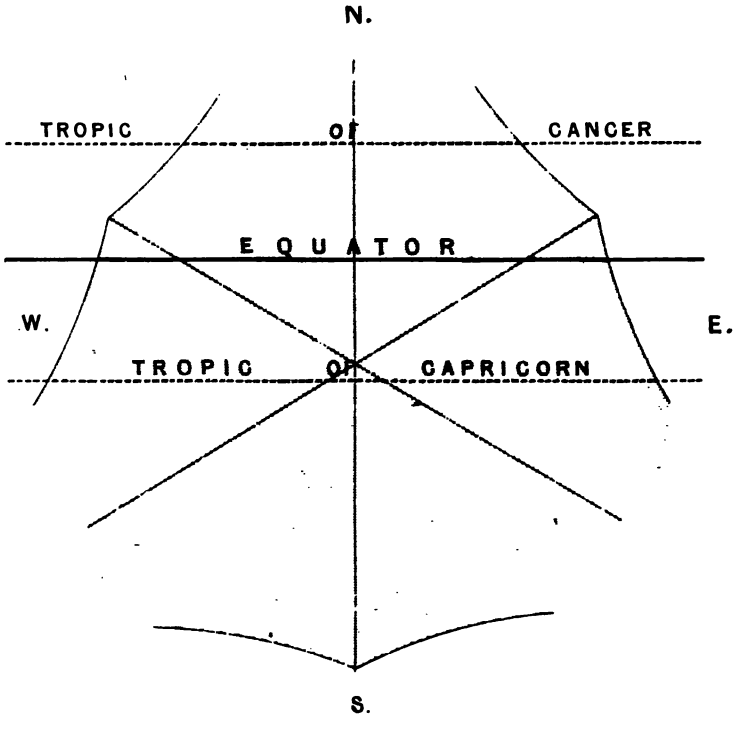
* It seems hardly necessary to call attention to the analogy between this purely mechanically derived figure and the continent of Africa. This and the next figure (2) are the analogues of continents and oceans respectively. They not only represent their shape, but their position on the crystal is the normal position of lands and seas on our planet.

† Guyot says: "The Pacific, the Indian Ocean, the Atlantic, correspond to the three double worlds which we have distinguished, following Steffens, and separate them from one another. Each of them also is divided into a northern and a southern basin, except the Indian Ocean, which, on this account, is only a half ocean."

(The Aralo-Caspian depression happens to be just cut off from the waters of the ocean, which have been evaporated in that depression.)

"*The general forms of the contours of these three oceans have, as a common feature, a wide opening towards the south, and are narrowed to a point on the north, just the reverse of the continents.*" The italics are mine.—'Earth and Man,' by Arnold Guyot, late Professor of Physical Geography and History, at Neufchatel, Switzerland. Boston. 1855. Page 78.

FIGURE 2.



First. Why most of the land of the globe should be in the Northern Hemisphere, and why it should stretch eastward and westward along parallels of latitude to the northward of the Equator, following the transverse acute solid edges.

Second. We see why there should be three continents mainly in the Northern Hemisphere, with a pyramidal projection to each, pointing into the Southern Ocean.

Third. We see why there should be a polar basin and an Arctic ocean surrounding the North Pole.

Fourth. We perceive why, as has often been remarked by physical geographers, there should always be water on the opposite side of the globe to which there is land, that land and water should be usually antipodal,* just as there is an obtuse or depressed solid angle opposite each acute, or solid angle in relief, on the crystal.

And, *lastly*, we perceive not only why the Southern Hemisphere in middle latitudes should be mainly ocean, with three triangular masses pointing into it, but we find a three-cornered continent occupying the South polar regions, just as a projecting, six-faced or three-lobed solid angle occupies the South Pole of our crystal.

The surface of the solid crust of the globe is thus contemplated as having a form of its own independent of the spheroidal shape,† assumed by the surface of the liquid ocean in obedience to the centrifugal force of rotation, and which fluid covers about three fourths of its area, and anticipating that the hardened crust (or the now solid earth, if solid it be), having cooled from a molten state, may exhibit a more or less close approximation to some crystalline form, having a regular figure also; the spheroidal surface of the ocean cutting that solid and forming the water lines or coasts, becomes contour lines, which indicate what that regular figure is.

* That water should often be antipodal to water arises necessarily from the fact that there is nearly three times as much water as land.

† The influence on the form of continents of the spheroidal figure assumed by the surface of the ocean on the earth, as compared with the effect of the spherical figure, imagined to be assumed by the water on the model, will be referred to in its proper place.

CHAPTER II.

More detailed comparison by maps between the figure of the earth and a six-faced tetrahedron.

NOTWITHSTANDING this broad general correspondence between the reliefs and depressions on the crystal the six-faced tetrahedron and the reliefs and depressions on the solid crust of the earth, there appear a number of anomalies in the latter which require explanation, if we are to assume that its figure has any connection with that crystalline form. To enable us to examine these anomalies more minutely and to trace the coincidences and the divergences of the two figures, let us make use of Beaumont's methods, and apply the *réseau* or net of the six-faced tetrahedron to the terrestrial globe, by imagining the projection of planes through the centre of the figure and the solid edges of the crystal, on to a sphere.

This net, which may be made of wire and applied to a globe, is composed of six great circles, three of which correspond to circles of longitude passing through the North and South Poles 60° from each other, whilst the other three pass transversely to these, 60° from each other, and tangent to latitudes 35° 16′ North and South respectively. If we assume, as before, that one of the obtuse solid angles is at the North pole, the other three obtuse solid angles would then appear in latitude 19° 28′ South, 120° from each other; whilst the four acute solid angles would appear, one at the South Pole, and the other three in latitude 19° 28′ North, 120° from each other, and 60° from the longitudes of each of the three antipodal obtuse solid angles. Thus each one of the six great circles would be divided by three great circles into six equal spaces of 60° each, and which represent the thirty-six edges of this crystal, and which again represent the boundaries of the twenty-four equal and similar scalene tri-

angles by which this solid is bounded, and of which triangles, four sets of six each compose the four obtuse six-faced solid angles, and other four sets of six each compose the four acute six-faced solid angles. Thus this crystal may be viewed in two opposite aspects, that is, as possessing four flatter sides of six faces each, or four projecting corners of six faces each. These thirty-six edges are divided by crystallographers into twelve longer, twelve shorter, and twelve intermediate, but they are necessarily represented of the same length by the *réseau*, it being practically impossible to represent the true figure of the earth on the small scale of a map or a globe; but on the surface of the solid earth itself there are no great circles, and properly executed geodetic operations should show an approximate corresponding difference of length of the astronomical degrees, along each tetrahedral edge of the *solid* crust, which would exist in a true six-faced tetrahedron with convex faces of the size and proportion of that of our earth.

But the most important point to be noted at present with regard to these crystalline edges is that upon any possible six-faced tetrahedron the thirty-six edges are composed of twelve relatively acute and twenty-four relatively obtuse angles, and bearing in mind that the centre of gravity and the centre of this figure correspond, it will be evident that the twelve acute edges are farther from the centre than are the twenty-four obtuse edges.

In other words, when the net of this crystal is applied to the *solid* crust of our earth, the twelve acute edges should represent lines of relief, and the twenty-four obtuse edges, lines of comparative depression. In constructing the temporary illustrative maps, therefore, all these edges are indicated on the *réseau*, the twelve acute edges or those of relief being coloured red, and the twenty-four obtuse or more depressed edges, blue.

It is usual to represent the world in one sheet on Mercator's projection, or in two hemispheres on the globular projection. Both methods are particularly unsuited to exhibit the facts which have to be presented, as it is well known they seriously distort the forms which they profess to delineate; whilst Mercator's projection is utterly inapplicable to the two polar regions, which in

a representation of the figure of the earth are of paramount importance.

There is no plan known which can represent even one hemisphere on a flat surface and preserve the figures of the land and oceans in their true relative proportion. The difficulty is lessened, however, if instead of depicting half the world on one map, we show one fourth only of its surface at a time. A photograph of one fourth part of the surface of an ordinary globe as divided by the tetrahedral edges projected on the sphere, gives a map with comparatively small distortion of the forms of the different features. In truth there is no great advantage in mapping the world by hemispheres rather than by quarters, and it has probably heretofore been so delineated because no other large natural divisions have been recognized. On the principle of the six-faced tetrahedron, however, contemplating it either from the aspect of its four acute solid angles, or its four flatter faces, it will be seen that two sets of four great natural divisions of the earth present themselves, and by confining each division to one map on an orthographic projection, not only are the difficulties of distortion lessened, but what is of more importance the grand features of the earth's surface configuration are presented in two natural series or classifications, each map representing one acute or one obtuse solid angle of the six-faced tetrahedron.

The first set of four maps (Plate I.) shows the whole world on the four relatively acute six-faced solid angles of the six-faced tetrahedron, as bounded by the *réseau*, each map being upon one solid angle. Long. 30° E. is taken as the central meridian of the first map of this set No. 1, by which the *réseau* and the boundaries of all the rest of these maps become fixed. It is defined, as are the other three of the set, by the six obtuse solid edges which define a solid angle of the six-faced tetrahedron, the North Pole of a tetrahedral axis being in the centre, in long. 30° E. and lat. 19° 28′ N.—three acute solid edges (coloured red) and three obtuse solid edges (coloured blue) alternating and radiating from that centre to where they join the obtuse edges bounding the six-faced solid angle.

This map of an exact fourth part of the globe, thus definitely

bounded by the *réseau* of certain crystalline edges, exhibits the double continent Europe—Africa, nearly complete, a paring of the southern end of Africa being cut off. The land is well in the centre of the map, and the mass of it corresponds with the red lines or acute solid edges of the tetrahedron; whilst the three blue lines, or more depressed solid edges, take the shortest course to the centre of the three seas which surround this solid angle.

This map (as well as the other three, Nos. 2 to 4) is bounded by six blue or obtuse edges or lines of comparative depression, and the main anomaly in it, comparing it with our model crystal, is, that part of Asia in the east, shows as land where the analogy of the crystal and the blue edges lead us to expect ocean, and even the Aralo-Caspian depression, which might answer for it, is too far to the westward. Again, the great transverse depression of the Mediterranean Sea has no blue line to indicate it, and there is nothing analogous in the simple crystal; but as these two anomalous features are also encountered in the other two maps or solid angles which correspond to this one in position with relation to the axis of rotation of the globe, they will be considered and explained together.

The next tetrahedral map (No. 2) of the second quarter of the globe has its centre 120° from the centre of the last one, that is, in 90° W. long., and in the same latitude, 19° 28′ N. It contains, of course, an equal area, is bounded by similar blue edges of the *réseau*, that is, it represents another six-faced acute solid angle, and exhibits the double continent North—South America complete, with the exception of the projecting point of South America, and a small portion of North America in the west. The two red lines or acute edges which stretch to the N.E. and N.W., respectively appear to the southward of the similar trending mountain chains of North America which they indicate.

The north and south red line of relief or acute edge passes to the eastward of the great north and south chain of the Andes instead of coinciding with it. There is again a great transverse depression at the Caribbean Sea dividing North from South

America which is not represented by blue lines on the map, or by depressed edges on the model, and the easterly drag or set of South America compared with North America appears to take its origin at this transverse depression; whilst the West India Islands which are in it are twisted into a great double curved line, as if they were near the line of the lateral shift from the original position of the two portions of this continent. The next map (No. 3) of the third quarter of the globe has its centre or pole 120° westward again on 150° E. and in the same parallel of latitude as the centres of the other two, and is bounded in all respects by lines or edges of the *réseau* corresponding to those of the preceding two maps, and showing similar six faces composing an acute solid angle. This map exhibits what has been called the partially submerged double continent Asia—Australia, a slice of the southern end of the latter being however cut off. The north and south central red line corresponds with the north and south main Australian range. But there is presented a very striking anomaly to the northward. The transverse depression appears again dividing the continent at the Eastern Archipelago, but where the N.E. and S.W. red lines should indicate relief in land, we find mainly water;* whilst China, in accordance with what we have called the anomaly in the other two maps, appears pushed over to the westward. In agreement with this apparent westerly thrust of the land to the northward of the dividing depression of the Eastern Archipelago, the islands composing it and lying in that depression appear dragged, as were the West India Islands, into a double curved line, as if their heights might once have connected the two halves of this continent in a direct north and south line; but which now shows

* It is necessary again to bear in mind that although the agreement of the relative position of land and water on the earth and the red and blue lines on the map is used as a very good indicator of where the reliefs and depressions are, and how they correspond with the crystal, yet in certain shallow seas and certain low lands, it may be only a question of the difference of a few hundred feet whether there appears land or water; whilst the differences between the grand reliefs and depressions we are now considering have to be reckoned by vertical miles. It is not, therefore, of serious import in this inquiry, whether a certain area be just above or just below the surface of the ocean, so long as we know or can estimate that it is only just above or just below.

where the lateral displacement has occurred. Thus these striking anomalies in this view of the figure of the earth connect themselves together by a rule which should lead to their solution.

We now come to the last map (No. 4) of this series, which completes the map of the world. It is bounded, as the other three were, by the six blue edges of the *réseau* of an acute six-faced solid angle of the tetrahedron, and has its centre at the South Pole, and has precisely the same area as each of the others. This, the fourth quarter of the globe, exhibits the Antarctic continent complete, with the projecting points also of the other three continents which were cut off by the limits of the other three maps.

There is just enough uncertainty as to whether land or ocean surrounds the South Pole to create a special interest in this map. Some geographers write Antarctic Ocean there as confidently as others write Antarctic Continent, but it may be observed that whilst in three main directions towards the South Pole navigators have encountered high land, no ocean has been seen southward of that land. Discovery, as far as it has gone, plainly indicates a continent. Sir C. Lyell, in the latest (eleventh) edition of his 'Principles of Geology,' speculating on the cold of the Antarctic regions, sanctions the view of a probable continent there in accordance with the results of discovery, and in a map of the water hemisphere, by Mr. Trelawney Saunders, shows the probable shape and size of it. The agreement between the outline of the Antarctic continent as drawn in Sir C. Lyell's volume, and the one in Map 4, Plate I., which was sketched quite independently, is noticeable, although in fact they both merely give the form which discovery indicates to be the true one. It seems mutually corroborative of two independent ideas, that while Sir C. Lyell requires an Antarctic continent on meteorological grounds and shows it three-lobed as the probable shape, the tetrahedral view of the figure of the earth not only requires an Antarctic continent, but requires it three-lobed. Reference to the Map No. 4 will show how nearly the alternate red and blue lines coincide with the corresponding land and water projections; whilst the six bounding blue edges of the map pass

along deep ocean, except where they cut off projecting continental points, just as the obtuse or depressed edges of the crystal have to meet the acute edges, or those more in relief. It will be observed that this South polar continent is removed from the influence of the line of shift which affects the other three, and is therefore not likely to be found divided, depressed, or twisted from its normal three-lobed figure.

If now we contemplate the four flatter faces or the four obtuse six-faced solid angles of the same six-faced tetrahedron, on the *réseau* of the four acute solid angles of which we have drawn the world as divided into four continents surrounded by four oceans, and construct four other maps, each defined by the *réseau* of one of the four six-faced obtuse solid angles, and which are opposite to the acute ones, we have the next series which constitutes another map of the world, but from the aspect of the four great oceans. It will be unnecessary to recite the latitudes and longitudes of these maps, and it will suffice to state that they occupy precisely antipodal positions to the maps of the continents, each number on one series being antipodal to the corresponding number on the other series, just as there exists an obtuse solid angle opposite each acute solid angle on the crystal. It will be seen that they are each bounded by red edges, or edges of relief, instead of by blue edges of depression as the continental maps are, and that six blue edges converge in each map from the circumference to the centre. To perceive to what extent the real reliefs and depressions of the earth's *solid* surface agree with the predetermined red and blue lines of the crystalline *réseau*, it is only necessary for the present to glance at the series of maps; but in estimating their bearing and importance in this comparison, it will be borne in mind that the four oceans have not been arbitrarily placed one on each map, as a cursory view of them might lead one to suppose; the fact being, that a spot on the surface of the earth having been determined upon to agree with a spot on a six-faced tetrahedron, every red and blue line, and therefore the bounding edges of each and all of the maps, are precisely and arbitrarily defined by the edges of that crystal. The four flatter sides of the crystal are then found to coincide with

the four oceans of the earth to the extent which these maps show, which is perhaps more complete and striking than the agreement of the four continental maps with the four solid angles in relief. These four maps show at a glance also how many oceans there are; they present the question, however, whether portions of the North Pacific and North Atlantic may not more strictly belong to the Arctic basin.

But omitting from our consideration for a moment the tetrahedral theory of the figure of the earth's solid crust, these two series of maps exhibit noteworthy facts; for it is a remarkable circumstance that the four central points, or the normals to the faces, of the four great oceans of the globe should be so nearly inclined to each other at an angle of 109° 28′, the same as the great faces of the Kohinoor diamond, and that the central points of the four great continents of the globe should be so nearly opposite to these ocean centres. It is remarkable that the abnormally great Pacific Ocean (Map No. 1, Plate II.) should be precisely antipodal to Map No. 1, Plate I., containing the abnormally large continent Europe—Africa; that the medium-sized Indian Ocean (Map 2, Plate II.) should be opposed by Map 2, Plate I., containing the medium-sized continent North—South America, whilst the small Arctic Ocean (Map 4, Plate II.) has directly opposite to it the small Antarctic continent in Map 4, Plate I.; and when we compare the abnormal Atlantic (Map 3, Plate II.) into which South America appears to have been pushed with its antipodal map of the abnormal and half-drowned continent of Asia—Australia (Map 3, Plate I.), it is still remarkable to find that in the quarter of the globe opposite to that in which land has usurped the place of water, water has usurped the place of land.

Although perhaps a similar cloud to that which veils from us a clear view of the Antarctic continent still hangs over the Arctic Ocean, each navigator who penetrates it tells of more sea, just as each one who succeeds in approaching the South Pole reports land. The law which we see exists of land having water antipodal to it will hardly fail us here; and on this tetrahedral view of the earth, each explorer of new sea within the Arctic

circle becomes another witness to the probability of an Antarctic continent, whilst each discoverer of land within the Antarctic circle brings still more valuable testimony to the probability of a North polar ocean.

Thus these two series of maps seem to illustrate that the figure of the solid crust of our earth is based upon that of the tetrahedron, and that it has been, and probably is now, changing from an ellipsoid of revolution towards that form—a form which is the first of the five regular solids, having the smallest possible number of sides, and one of those "Platonic bodies" to which the ancient geometricians, with prophetic instinct, ascribed mysterious properties on which the explanation of the most secret phenomena of nature depended.

These maps also show that the ancient "Four Quarters of the Globe" is no longer a conventional phrase, but the expression of a physical fact, the result perhaps of a geometrical necessity, which will be considered in the next chapter.

CHAPTER III.

Physical connection between the tetrahedral figure and a molten spheroidal mass on which is forming a solid crust.

HAVING shown a marked general agreement to exist between the figure of the solid crust of our earth, and that of a six-faced tetrahedron with convex faces, and before pointing out more minutely where the earth's figure has diverged from that of the simple crystal, and why; it may be profitable to inquire whether any physical or mechanical cause can be conceived to exist which would necessitate or tend to produce that figure in the solidifying crust of a molten spheroidal mass contracting its dimensions by loss of heat—for that is the condition in which the astronomer regulates our globe to the researches of dynamical geology, whether it be now solid or fluid at the centre, whether its cooled crust be to-day thick or thin.

Leaving on one side for the present the somewhat doubtful proposition, that the earth may have solidified first at its centre or simultaneously with the cooling crust, let us assume that in accordance with the usual experience of cooling liquids, it began to acquire a hardened superficial crust. We have then presented to us the problem—how will a spheroidal crust collapse? for as soon as a solid crust is formed, gravity then becomes a force acting nearly equally in all directions to collapse the crust on to the shrinking fluid interior, and if it be urged that at first the thin crust might contract more rapidly than the molten nucleus, that stage will at last be passed, and, as all physicists admit, the nucleus will contract more rapidly than the crust. The mode of collapse of the crust, however, would probably be the same whether it arose from the gravity of the crust, or from its contracting more rapidly than the nucleus, that is from elastic tension.

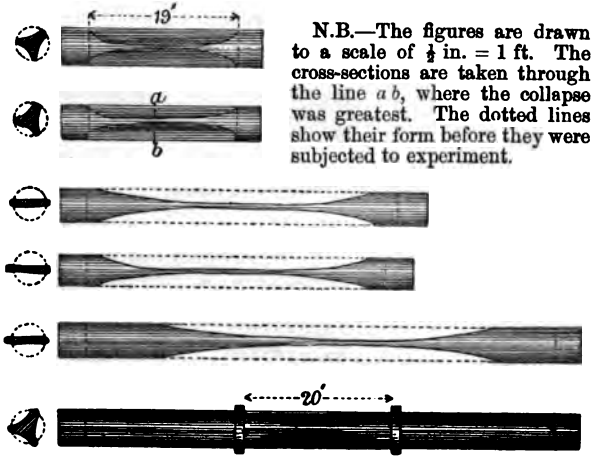
In order to lead us to the probable mode of collapse of a spheroidal crust, let us ask how a truly spherical homogeneous crust of equal thickness will probably collapse under an equal pressure from all directions. I am not aware that this question has been considered either theoretically or experimentally. Fairbairn made a great many experiments on the collapse of hollow glass spheres, but nothing could be inferred as to *how* they collapsed,* because they "were reduced to the smallest fragments, in some cases a great part almost to powder, by the violence of the concussion." Inasmuch, however, as a spherical shell may be considered as consisting of an infinite number of circular rings, and as Mr. Fairbairn has shown in considerable detail how circular rings or tubes collapse under pressure, we may, perhaps, obtain some light from experiments on these. The following (Fig. 3) is a facsimile of his first two tables and plates, showing how 4-inch and 6-inch wrought-iron tubes under pressure:

It will be observed that there were six 4-inch and six 6-inch tubes experimented upon, marked A to M, or twelve tubes in all. The experiment on M was vitiated by a tin ring having been left in it by mistake. Of the other eleven tubes, four became flattened, and seven collapsed from three directions at about equal distances apart. The four tubes which flattened, however, were the long tubes, in which the inequality in thickness or flaws in the material increased the chances of not giving a normal result. All the short lengths, without exception, collapsed from three equidistant directions, showing a three-cornered or three-lobed section after collapse, or a similar section to that of a tetrahedroid taken at right angles to any tetrahedral axis. But if a true spherical crust may be expected to assume a tetrahedroidal figure under compression or gravitation towards the centre (which are equivalent forces), we may also expect a spheroidal crust to do so, for although the two flatter poles might theoretically be expected to yield first and together, yet if one happened to yield, as in fact is more probable before, the

* 'Fairbairn's Useful Information for Engineers.' 2nd series. Page 75. London. 1860.

TABLE I.—RESISTANCE OF 4-IN. TUBES.

Mark.	No.	Diameter.	Length.	Thickness of Plates.	Pressure of Collapse.	Remarks.
		in.	in.	in.	lbs. per sq. in.	
A.	1	4	19	·043	170	
B.	2	4	19	·043	137	
C.	3	4	40	·043	65	
D.	4	4	38	·043	65	
E.	5	4	60	·043	43	
F.	6	4	60	·043	140	



N.B.—The figures are drawn to a scale of $\frac{1}{8}$ in. = 1 ft. The cross-sections are taken through the line $a\,b$, where the collapse was greatest. The dotted lines show their form before they were subjected to experiment.

TABLE II.—RESISTANCE OF 6-IN. TUBES.

Mark.	No.	Diameter.	Length.	Thickness.	Pressure of Collapse.	Remarks.
		in.	in.	in.	lbs. per sq. in.	
G.	7	6	30	·043	48*	
H.	8	6	29	·043	47*	
J.	9	6	59	·043	32	
K.	10	6	30	·043	52	
L.	11	6	30	·043	65	
M.	12	6	30	·043	85†	

* On removing the tubes G, H, it was found, that owing to the thinness of the metal, the cast-iron ends of both had been fractured, causing collapse, perhaps, before the outer shell had attained its maximum resistance.

† Tube M had an iron rod down its axis to prevent the ends approaching each other during collapse; a tin ring had also been left in by mistake, which accounts for the increased pressure required to produce collapse.

other, the tendency would be to force the opposite crust outwards, both through the interaction of the forces in the crust itself, and through the medium of the internal fluid. The spheroidal crust would then be brought approximately to the figure of a spherical crust under collapse. In other words, a spheroidal crust would be more readily collapsed tetrahedrally than a spherical crust, for it has one flat side (in practice probably slightly weaker than the other flat side) at which the collapse would commence.*

A practical illustration of the form which a globular or rather a spheroidal fluid film will assume under pressure seems to be exemplified by an ordinary air bubble either in water or in air. An air bubble rising in water, if carefully watched from different aspects, will be seen to be very notably tetrahedroidal, except that the under flat side is forced inwards by the pressure upwards of the column of water which is raising the globule of air in spite of the pressure of the column above it, that is by the difference of pressure of the two columns. The top view of it as it rises is three-lobed: it presents a section of the Fairbairn collapsed tubes. Thus it will be seen to have four prominences and four depressions, as the tetrahedron or the earth has—the under flat face (the north pole), however, being unduly compressed, as might be anticipated under the circumstances.

A soap-and-water bubble floating in the air seems to have a similar form, if minutely examined, although the water hanging at the lower end tends to obscure it. If it be freed from this hanging water and allowed to rise or fall in air entirely free from currents, it will be found to rise or fall in a triangular

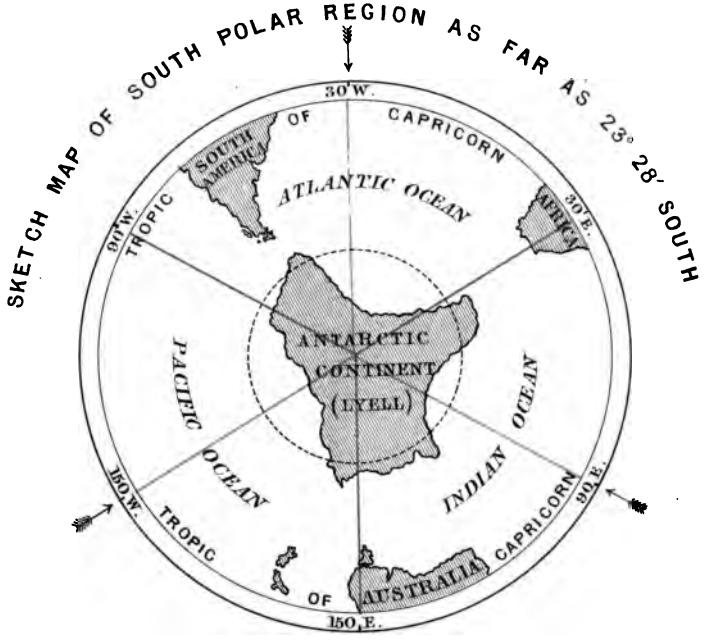
* The cause of these effects seem to be that an infinite number of equal forces acting on the circumference of a circle in one plane in the direction of the centre is equivalent to, or resolvable into, three equal forces acting on it from three equidistant points towards the centre in the same plane, or 120° from each other. And an infinite number of equal forces acting on the surface of a sphere in the direction of its centre, is equivalent to, or resolvable into, four equal forces acting towards its centre from four equidistant points, or 109° 28′ from each other. A ring can be stopped from moving in any direction in its own plane at three equidistant points, and not less. A globe can be stopped from moving in any direction whatever at four equidistant points, and not less.

path, just as the four-lobed air bubbles are seen to rise in water, or as a tetrahedral wooden model will rise in water.

The soap-and-water bubble in air presents a slightly tetrahedroidal form compared with the air bubble in water, because it is a delicately elastic film exerting a delicately compressing force on the enclosed slightly resisting air. The result is a delicately tetrahedroidal figure. This figure, which we may call a tetrahedroid of resistance to collapse, appears to be one which results as definitely from the circumstances as the spheroid of revolution is the definite mechanical result of another set of circumstances. It may be traced in many natural objects, where there exists a fluid interior and a hardened or tensile crust,* as in shell-fish, fruits, and nuts, and in none more distinctly than in the cocoanut. I have two picked out of a few dozen only which show the form very distinctly, and most nuts possess it more or less. The four continental elevations and the four oceanic depressions are clearly exhibited in the four prominences, and the four flatter sides of these two nuts. In the next chapter, treating of the astronomical evidence on this subject, I shall refer to the same figure predicable in the moon and probably in some of the planets. The diagram (Figs. 4 and 5) will exhibit the relation between sections of a collapsed wrought-iron tube, of a solid angle of a six-faced tetrahedron at right angles to an axis, and of the earth at the Tropic of Capricorn, or indeed through almost any parallel of latitude, showing in each case a collapse from three equidistant directions towards the centre.

* The film of a bubble is a crust in the light in which it is now viewed. It has tenacity and elasticity, and confines and compresses the enclosed air. The distinction between it and a steel crust is only one of degree.

FIGURE 4.



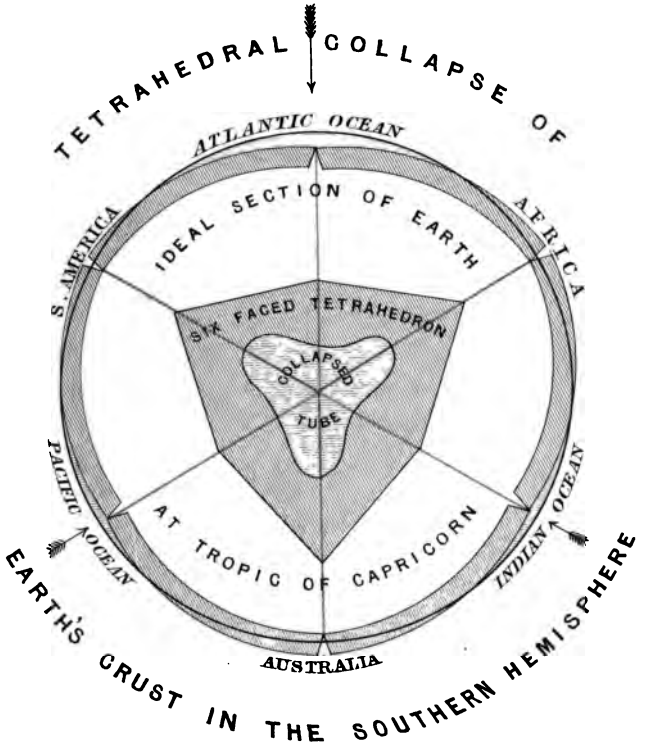


FIGURE 5.

CHAPTER IV.

Astronomical testimony to the tetrahedral figure of the solid crust of the earth in the inclination of the axis of rotation and in the angle of it — Tetrahedral figure predicable in the moon, and occasionally in Saturn and Jupiter — What the satellites of Uranus indicate.

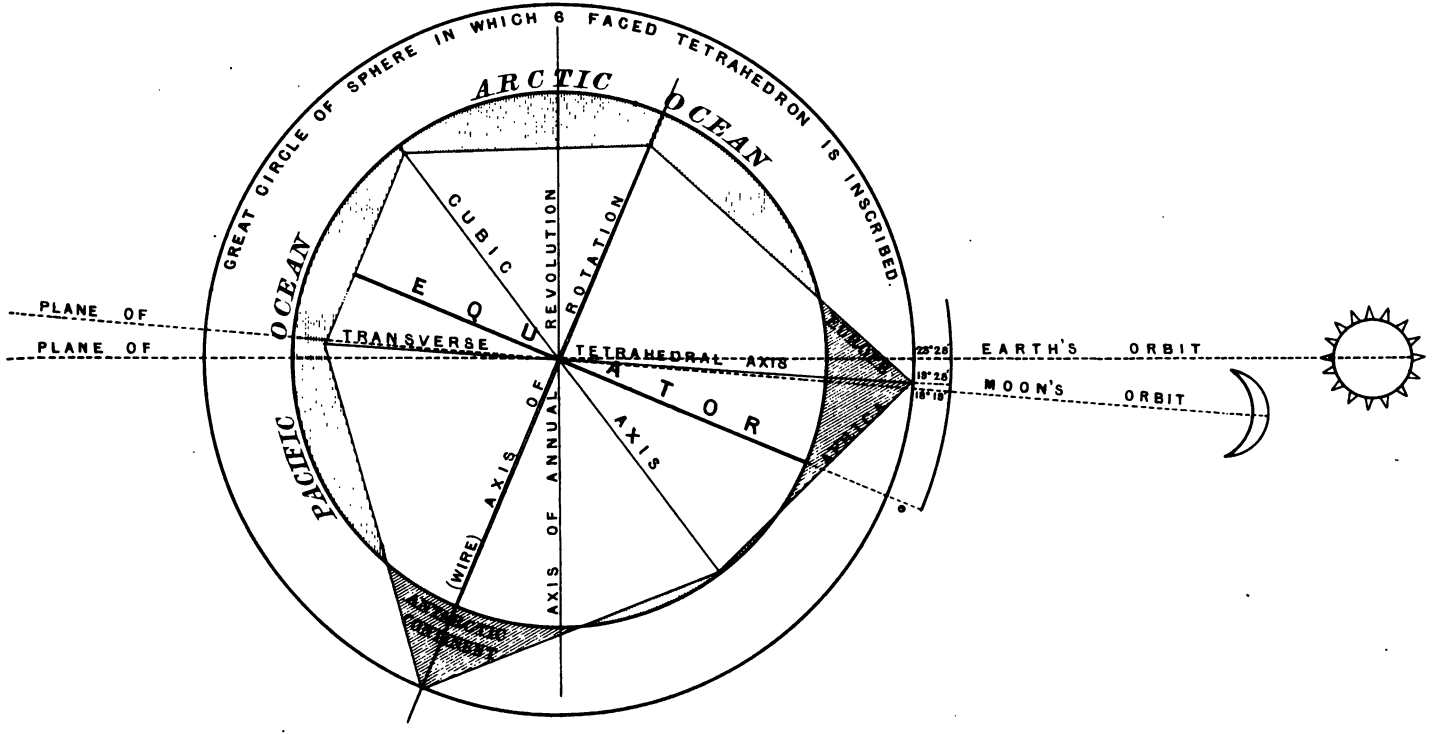
If in the only intelligible account ever suggested of the evolution of planets we go back to the period when our earth is assumed to have been a molten mass, rotating on its axis and revolving round the sun in the same direction as it and the sun rotate and in the plane of its equator, and with the axis of rotation at right angles to that plane, most of the phenomena seem to accord with the nebular hypothesis. There exist, however, at this day some striking facts in the planetary system which do not seem to agree with the requirements, and which have been left as outstanding or unexplained circumstances in a theory otherwise singularly consistent. None of these have been considered more difficult to reconcile than the fact of the present inclination of the axis of rotation of the planets to the plane of their orbits. The normal expectation from Laplace's theory is, that the axis of rotation of each planet would be found at right angles, or 90° to the plane of its orbit, instead of which it is usually inclined. In the case of the earth that inclination is 23° 28′ from 90°, or 66° 32′ from the plane of its orbit. No definite geometrical or mechanical cause has been recognized which might account for this tilt in the earth's axis of rotation.

To reconcile the theory and the fact, and to present an adequate cause not only for a change of inclination of the earth's axis of rotation from the perpendicular to the plane of its orbit, but for the amount of that change of inclination, it is only necessary to show the probability that the earth having been once a molten spheroid of revolution, and having its axis at right angles

to the plane of its orbit, in acquiring a solid crust by radiation of heat induces in that crust a tetrahedral figure, as assumed in the preceding chapters; because a tetrahedron (six-faced or otherwise) rotating on a principal axis under the influence of an attracting body, and having the radius vector in the plane of the tetrahedral equator, could not remain in that position, inasmuch as its centre of gravity would not be in the plane of the radius vector, it would therefore incline its axis of rotation until the other three tetrahedral axes, or the mean centre of gravity coincided, as it rotated with that plane.

In the case of our earth changing its figure tetrahedrally by collapse of the north pole and three corresponding poles, whilst the mean plane of attraction of the sun and moon was coincident with the plane of the earth's equator and at right angles to its axis of rotation, the tilt of the axis of rotation would evidently be governed mainly by the moon and then by the sun, whilst the influence of the planets may be neglected. The moon's power in this species of attraction is usually estimated as in the tides and in precession at 2·50 to the sun's one, or as $\frac{5}{7}$ths for the moon's influence, and $\frac{2}{7}$ths for that of the sun. If, then, we assume the earth to be truly tetrahedral (and it might be strictly so with regard to the relations of its axes to its centre of gravity, and still be not far from spherical), the three transverse axes which pass through the centre of gravity, and the remaining axis of rotation would be, when coincident with the plane of attraction of the moon and sun, the only possible positions of repose for a planet possessing that figure. As the earth, therefore, rotated on that one of these axes which was perpendicular to the plane of its orbit, the other three transverse tetrahedral axes would tip until they coincided as they rotated with the mean plane of the attraction of the moon and sun. These three transverse axes are inclined in a tetrahedron 70° 32′ from the other axis, or that of rotation in the case of the earth and from each other, and would coincide with lines drawn from latitudes 19° 28′ north to 19° 28′ south upon the earth as shown in the tetrahedral maps; so that upon this theory our earth should have tipped till a line joining latitudes 19° 28′ north and

FIGURE 6.


GREAT CIRCLE OF SPHERE IN WHICH 6 FACED TETRAHEDRON IS INSCRIBED.
ARCTIC OCEAN
PACIFIC OCEAN
CUBIC
EQUATOR
TRANSVERSE
TETRAHEDRAL AXIS
AXIS OF ANNUAL REVOLUTION
AXIS OF ROTATION
(WIRE) AXIS
PLANE OF
PLANE OF
23°28'
19°28'
18°18'
EARTH'S ORBIT
MOON'S ORBIT

south coincided with the mean plane of attraction of the moon and sun. The plane of attraction of the sun (or of the earth's orbit) coincides with lines drawn between latitudes 23° 28′ north and south, but the mean plane of the moon's orbit is inclined 5° 9′ to the plane of the earth's orbit, and when the aspect of the plane of the two orbits is similar, the plane of the moon's orbit coincides with lines drawn between latitudes 18° 19′ north and south. Thus the actual plane of the sun's attraction being in latitude 23° 28′, and that of the mean plane of the moon's attraction in 18° 19′, it is evident that the tetrahedral transverse axes in lines joining latitudes 19° 28′ north and south appear close to where the theory places them, that is, nearer the plane of attraction of the moon than of the sun by $\frac{5}{7}$ths of the whole difference of 5° 9′, or 3° 41′, which being deducted from 23° 28′ gives 19° 47′ as the calculated axes through the centre of gravity, instead of 19° 28′, a difference so small that this close agreement is probably accidental, because the plane of the earth's orbit itself is supposed to vary 1° 25′ in about 10,000 years, caused by the attraction of the planets. Besides which the apparent inequality in the faces of the crystal as exhibited in the abnormally large Pacific depression, or the somewhat irregular and symmetrical shift between the northern and southern tetrahedral crusts may be expected to produce more than this amount of irregularity in the poise of the earth, viewed as a six-faced tetrahedron. The annexed diagram (Fig. 6) shows a section of the model six-faced tetrahedron (with the circumscribing sphere) having the water surrounding it concentrically, as referred to in Chapter I., and taken in the plane of any one of the great meridian circles corresponding to those crystalline edges, and showing the different axes coinciding with those planes, and the relation of the three transverse tetrahedral axes to the mean plane of the sun and moon's attraction.

These facts cannot but recall to mind Laplace's conception whilst contemplating the difficulties of the nebular hypothesis, that the inclination of the axes of rotation of the planets were probably connected with movements occasioned by loss of heat whilst they were condensing. This movement may have taken

place at a comparatively late period, and long after the planets had assumed a liquid state as here suggested.

Mr. Samuel Mossman in a curious work, called the 'Origin of the Seasons considered from a Geological Point of View,' published in Edinburgh in 1869, called attention in a very definite manner to the excess of matter in the northern hemisphere, as the probable cause of the inclination of the earth's axis. He also gives in that work, page 41, a diagram of an approximate section of the globe through two opposite meridians, but exaggerated in vertical dimensions to explain his view that the earth is "top-shaped."

The tetrahedral view of the earth's figure makes it also "top-shaped" in a certain sense, but sections of the earth through two opposite meridians are not "top-shaped," the peculiarity being that there is a flat side opposite to each of the three more projecting sides (see Fig. 6).

In the illustration by a top the grand tetrahedral depressions are only partially recognized.

I purposely omit in this place the consideration of the connection of the changes in the inclination of the earth's axis with the tropical fossil fauna and flora found in northern and even arctic latitudes, as the subject is a wide and complex one, and by no means explained by such a tilt, and it can hardly be successfully grappled until our ideas of the figure of the earth, the thickness and movements of its crust, and the nature of its interior are more satisfactorily determined than they are at present.

It may be that the tropical strata have been moved with the earth's crust bodily northward along the line of shift between the two hemispheres, in the manner suggested by Mr. J. Evans; nor can we omit in such an inquiry the probable effect of an evagation of the poles, or real change of axis of rotation of the crust, as long ago suggested by Sir Henry James, although the tetrahedral collapse alone, being a symmetrical one, would not change the actual poles: it would change their inclination only.

The inquiry will naturally occur, if the earth's crust is

tetrahedral to such an extent as to have influenced definitely the inclination of the axis of rotation by the attraction of the sun and moon on that figure, what becomes of those calculations respecting precession and nutation which agree so well with the assumption of a different figure, namely, that of a spheroid of revolution? It is evident that whatever figure the solid crust of the earth may possess (within the probable limits of variation) the centrifugal force of rotation must produce an equatorial bulge in the fluid ocean which surrounds it, as well as a tendency to a similar equatorial bulge of the fluid nucleus, which may modify the tetrahedral figure of the solid crust. We may consider our earth, then, as made up of two figures, the six-faced tetrahedron and a spheroid of revolution in a manner analogous to a compound crystal, each of which figures might be acted upon independently by the attraction of the sun and moon. For we may conceive that a solid tetrahedron with a solid equatorial ring attached to it would have been influenced by those attractions precisely as the earth is here assumed to have been influenced, if placed in similar circumstances. It would first have inclined its tetrahedral axes to the plane of the mean attraction, the equatorial ring remaining neutral or with the same centre of gravity as before, but that inclination would then for the first time place the ring in a position to allow of a difference in the attraction by the sun and moon of its near and far side, producing precession and nutation, uninfluenced by the tetrahedral figure which has now, by inclining, obtained a position of repose and become neutral, as the equational ring was when the mean plane of attraction coincided with a plane through its centre at right angles to its axis of rotation. The movement due to precession it will be remembered produces no effect on the inclination of the earth's axis, but only a change in the aspect of the plane of its rotation, and that due to nutation produces only a temporary effect which is corrected by rotation, and the return of the moon's orbit to its original aspect every 19¾ years. The tetrahedral figure of the earth therefore need have now no perceptible influence on the movements due to the attractions of the sun and moon on the near and far side of the equatorial bulge, although it was precisely

the change to the tetrahedral figure in the first place which brought the earth into a position to be effected by precession and nutation at all.

Have we any indications of a tetrahedral figure in the other bodies of our system? The moon has long been believed to have a prolate face pointing to the earth* and a flatter side away from it, and its centre of gravity has been shown to be some thirty-three miles farther from the earth than the centre of its figure, or than the centre of what has been assumed to be its figure. If the figure of the moon be tetrahedral, however, with one of its four acute solid angles pointing to the earth, the centre of gravity may still be in the centre of the figure, although thirty-three miles farther from this side of the moon than from the opposite side, just as each of the four axes of a six-faced tetrahedron has a longer and shorter half axis. The assumption of this figure for the moon will at the same time account for some otherwise inexplicable circumstances connected with its movements.

It has already been explained in the case of the earth, that a rotating tetrahedron revolving round an attracting body in the plane of its equator would tend to incline its axis of rotation till the other three tetrahedral axes came into the plane of attraction of the attracting body. Assuming the moon then to have changed to that figure under these circumstances, the fact of its now appearing to rotate on its axis in precisely the same time and in the same direction as its monthly revolution round the earth becomes intelligible, for whatever may have been its original direction and rate of rotation, the attraction of the earth on an acute tetrahedral angle may have first tilted that angle towards the earth and then stopped its original rotation altogether. The fact that this constant pointing of one face of the moon to the earth may be explained by the supposition of a rotation of the moon on its axis in exactly the same time as it takes to revolve round the earth, is not conclusive evidence in

* The prolate face noticeable in many photographs of the moon has been ascribed to the effect of the focussing and exaggerating the nearer parts. This may increase the effect, but it is probably also a representation of the prolate face which actually exists.

favour of a real rotation of the moon on its axis, for on this tetrahedral view of the moon's figure there would be no principal axis on which it could continue to rotate in the direction in which it appears to rotate. What have been considered the remarkable coincidences and circumstances connected with the moon's rotation and revolution, may be merely a misconception of the facts.

Laplace, indeed, in his 'System of the World,' vol. iv., p. 218, *et seq.* (London, 1809, translated by J. Poid, F.L.S.), indicates this condition of the moon, and the effect of it on its motions, and we cannot do better than quote his own language: —"We may easily conceive," he says, "that if the greater axis of the moon deviates a little from the direction of the radius vector, which joins its centre with that of the earth, the terrestrial attraction will tend to bring it down to this radius in the same manner as gravity brings a pendulum towards the vertical." Again he says: "It would be against all probability to suppose that these two motions"—the moon's rotation and revolution—"had been at their origin perfectly equal, but for the explanation of this phenomenon it is enough that their primitive difference was but small, and then the attraction of the earth would establish the equality which at present subsists." Again, at page 221, he says: "The singular phenomenon of the coincidence of the nodes of the equator of the moon with those of its orbit, is another consequence of terrestrial attraction." . . . "The planes of the equator and of the orbit of the moon, and the plane passing through its centre parallel to the ecliptic, have always very nearly the same intersection; the secular motions of the ecliptic neither alter the coincidence of the nodes of these three planes, nor their mean inclination, which the attraction of the earth constantly maintains the same" . . . "the preceding phenomena," he observes, "cannot subsist with the hypothesis in which the moon, originally fluid and formed of strata of different densities, should have taken the figure suited to their equilibrium. They indicate between the axes [or half axes, W. L. G.] of the moon a greater irregularity than would take place in this hypothesis. The great inequalities which we

observe at the surface of the moon have without doubt a sensible influence on these phenomena." Inequalities perhaps in the moon's figure, not irregular and arbitrary, but symmetrical, the result of a tetrahedral collapse "occasioned by loss of heat."

We are indebted to Mr. Proctor* for having brought within the range of popular knowledge, that the planet Saturn has on different occasions exhibited to Sir William Herschel and other astronomers what has been called "the square-shouldered aspect" which has been sometimes explained as a flattening of the equatorial regions. "On another occasion," he says, "Mr. Airey noted the exact reverse, the planet seeming flattened instead of upheaved in latitude 45°. Again, speaking of the eminent observers, Bond, father and son, he observes that they "noticed that in 1855–57, when the ring was most widely opened, the polar regions did not always seem projected farthest on the outer ring in a symmetrical manner, but four times on the left of the pole, once on the right, and once only exactly opposite the pole." The outline of this region also occasionally appeared irregularly flattened and distorted. "Now," he remarks, "there can be no doubt whatever that the planet Saturn is not ordinarily distorted," and he proceeds to show that in all probability Saturn as well as Jupiter, whose disc also sometimes exhibits partial flattenings, are in a wholly molten state.

Now if we may conceive that these molten planets are in process of forming crusts, not probably true solid crusts, but such tough and plastic ones as are often found over the lava lakes of Kilawa, and that when so formed the contraction of these vast films may act like the envelope of a bubble, the tetrahedroidal form would necessarily result, and remain as long as the crust remained entire. The rotation of a tetrahedroidal planet with its axis inclined 31° 19′ to its orbit, as Saturn's is, might alternately present all the forms of so-called "distortion" which have been noticed, when viewed in profile; although the real figure of the planet may have been a regular symmetrical tetrahedroid. These molten masses would, however, change again to the true spheroidal form when the viscous crust or film broke up and

* 'Other Worlds than Ours,' p. 168. 1871.

melted. There seems to suggest itself also a very probable cause for the temporary formation of a crust on them, for as they are usually covered by a dense cloudy atmosphere, any combination of circumstances which lessened or lightened it might allow of an enormous radiation of heat, which might well cause a viscous crust to form, to be remelted when the atmosphere assumed its normal state.*

When it is remembered that the mean density of Saturn is about that of alcohol, and that therefore its exterior portions must be less than that, whilst these extraordinary changes of figure are visible at a distance of four hundred millions of miles, it presents itself to us in the aspect of a gigantic bubble filled with a light molten fluid, and may be conceived to be capable of taking a similar form. As Saturn has often been noticed to present this distorted figure and to a wonderfully large degree, whilst merely "partial flattenings" can be with difficulty detected in Jupiter, so we find that the axis of rotation of the former has inclined proportionately to the plane of its orbit (31° 19′), whilst that of the latter has only tipped 3° 45′ from its assumed original angle of 90° to the plane of its orbit. Such enormous prominences in one hemisphere of a planet, although only occurring periodically or intermittingly and from whatever cause, *must* produce an inclination of the axis of rotation, if originally that axis was at right angles to the plane of its orbit.

The tetrahedral collapse of the crust of a planet, the spheroidal ellipticity of which is large, would result in its having the transverse axis through the centre of gravity thrown more towards the tetrahedrally flattened pole than 19° 28′ from the equator, and this effect of throwing up one hemisphere by the collapse of the other (there being three centres of depression in one hemisphere and only one in the other) may be imagined to

* The molten lava in the lakes of Kilawa, when protected from radiating its heat by a cover of rock, as, for instance, in a cavern, keeps molten whilst the exposed portions acquire a crust. This crust again protects the lava underneath from radiating its heat, and when this becomes intensified by connection from below, it remelts the crust, which is, however, again reformed by radiation. This alternate melting and cooling is the normal action of the lava lakes of Kilawa.

be so extreme in some cases, as at length to cause the flattened pole of rotation to point to the sun or to the plane of the orbit of its own satellites, and finally by a still further tilting of the axis of rotation to reverse its poles, so that the rotation of the planet, although remaining in the same direction as before with relation to its own poles, would appear to us to be, in fact would then be, rotating the opposite way to that which the rest of the planets revolve and rotate.

As a largely spheroidal planet is capable of controlling the plane of the orbits of its own satellites, when small and sufficient time be allowed, the retrograde motion of those of Uranus may be in this way capable of explanation consistently with the nebular hypothesis.*

The inclination of the earth's axis of rotation to the plane of its orbit, then, seems to agree with and be the result of its having acquired the tetrahedral figure, whilst the moon and three planets have been shown to possess some remarkable and heretofore unexplained peculiarities which the attribute of that figure renders intelligible. A planet, a bubble, and a cocoanut may acquire the tetrahedroidal figure by the action of analogous causes, they may each be an example of what Humboldt concisely expressed in the case of the earth, the reaction between the solid crust and the fluid interior. It would only be in accordance with the usual simplicity of the movements and interactions of the heavenly bodies, if the position and form of the continents of the earth, the variation in its seasons, the moon's peculiar movements, the tilt of the axis of the planets, and the retrogression of the satellites of Uranus, be the result of this simple geometrical effect, the grand prime mover being the dissipation of heat, which seems to have presided at the birth and controlled the history of all the systems.

* The orbits of the moons of Jupiter, which has, however, only slightly inclined its axis of rotation, are nearly in the plane of that planet's equator. The orbits of the inner satellites of Saturn are in the plane of the planet's equator, but the outer one, which is three times as far off, has remained nearer the assumed original plane of the planet's equator, that is, nearer to the plane of the sun's equator. Its orbit is under less control of the equatorial protuberance of the primary.

CHAPTER V.

Certain coast lines and grand lines of rupture or fault on the earth's crust are on great circles at right angles to the plane of attraction of the sun and moon at the solstices and equinoxes.

BEFORE proceeding in the next chapter to treat of the great line of shift between the two halves of the earth's crust, which has so modified the simple six-faced tetrahedral figure and the earth's physiography, we must notice some of the most remarkable coast lines on its surface, the more so because they are amongst the most regular and persistent in a certain direction; they seem to have been produced before the great lateral shift, and they exhibit appearances of what has often been suggested, that many coast lines are not simply contour lines formed by the junction of the slopes of the land and the ocean level, but real lines of rupture and upheaval, or faults.

It was, I believe, Prof. R. Owen,* of Tennessee, who first called attention to these remarkable coast lines. Professor Peirce has also observed the same facts, but neither has, as far as I am aware, connected the phenomenon with any definite physical cause.

Prof. J. D. Dana† alludes to them in his 'Manual of Geology' in the following terms:—"That the outlines of the continents lie in the direction of great circles of the sphere; which great circles are in general tangential to the Arctic or Antarctic circles. By placing the north pole of a globe at an elevation of 23° 28′ (equal to the distance of the Arctic circle from the pole or the tropical from the equator), then on revolving the globe eastward or westward, part of these continental outlines, on coming down to the horizon of the globe, will be found to coin-

* 'Key to the Geology of the Globe.' 8vo. New York. 1857.

† 'Manual of Geology,' by James D. Dana. Philadelphia. 1867.

cide with it; and in elevating the south pole in the same manner, there will be other coincidences."

This is a very simple experiment, and the result is remarkable, the close coincidence of a large number of the main coast lines with the wooden horizon of the globe being very apparent, although nothing seems to be directly indicated by this form of the experiment as to the cause of the phenomenon; but by exhibiting the same facts from a slightly different point of view, they appear to explain themselves.

Incline the north pole of the globe 23° 28′ to the perpendicular, or 66° 32′ from the plane of the wooden horizon which thus represents the ecliptic (see Figs. 7, 8, 9, 10); that is, give the globe the real inclination which the earth's axis of rotation has to the plane of its orbit; then pass a wire perpendicularly and centrally round the globe at right angles to the brass meridian and wooden horizon, and so attached as to leave the globe free to revolve. Fix two balls or other objects (to represent the sun and moon) one at each side of the globe, or both on either side, and in the line of the intersection of the planes of the brass meridian and wooden horizon. We have then represented before us the sun, moon, and earth situated in their approximate relative directions with regard to each other at either solstice (as we choose to place the balls), and at the syzygies. Now revolve the globe slowly, and observe it on each side opposite the perpendicular wire; it will be found that all the main coast lines that coincide with the wooden horizon in Professor Owen's experiment in the two positions of the globe coincide with the perpendicular wire as they pass it, one set on one side of the globe and one set on the other. The wire represents a plane coincident with a great circle on the earth at right angles to the plane and direction of the attraction of the sun and moon at the period of either solstice, and when they happen to be in conjunction or opposition at those periods; or, in other words, it represents the great circle on the earth's surface in which the internal tide wave due to that attraction at that time would necessarily (if at all) rupture the solid crust of the earth, assuming it to be equally frangible in any direction.

Fig. 9

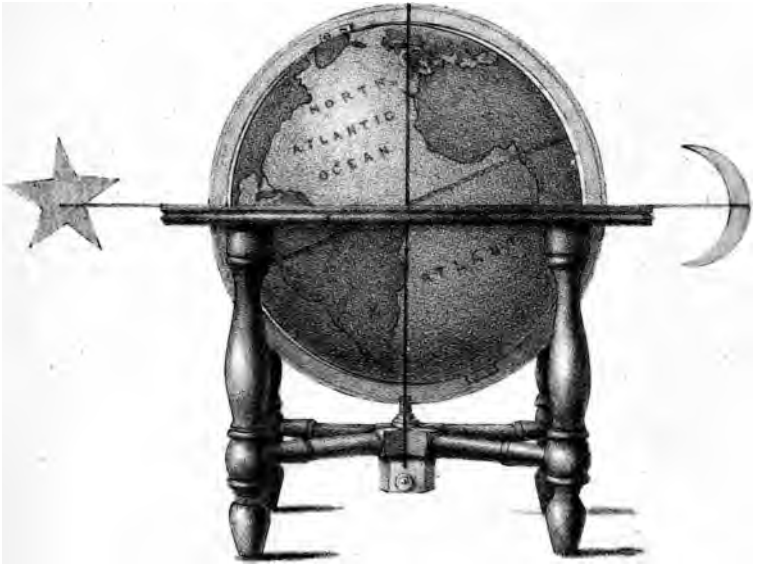


Fig. 10

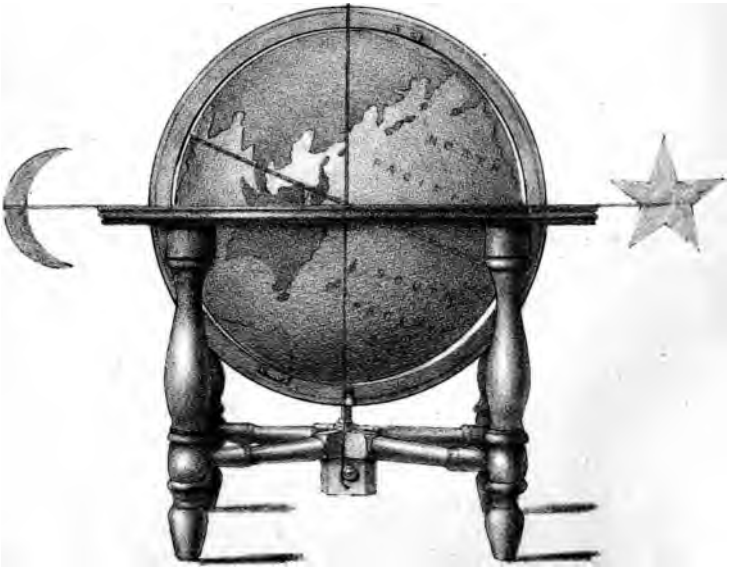


Fig. 7

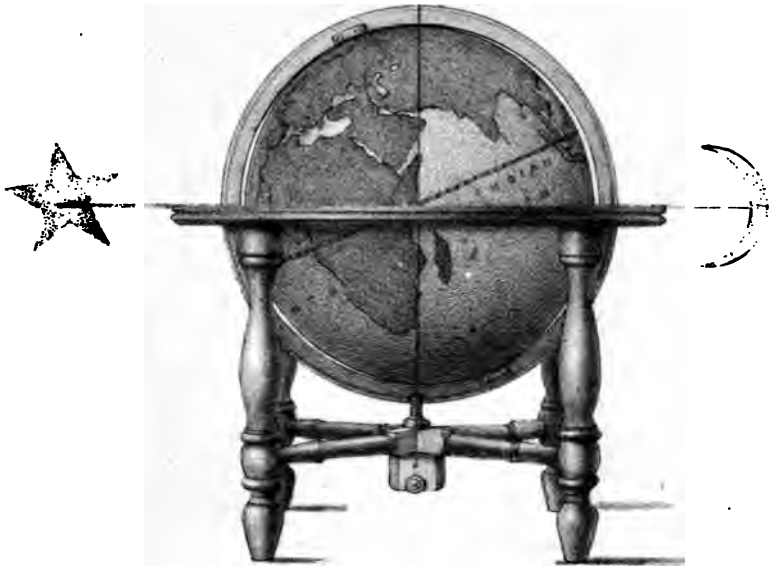
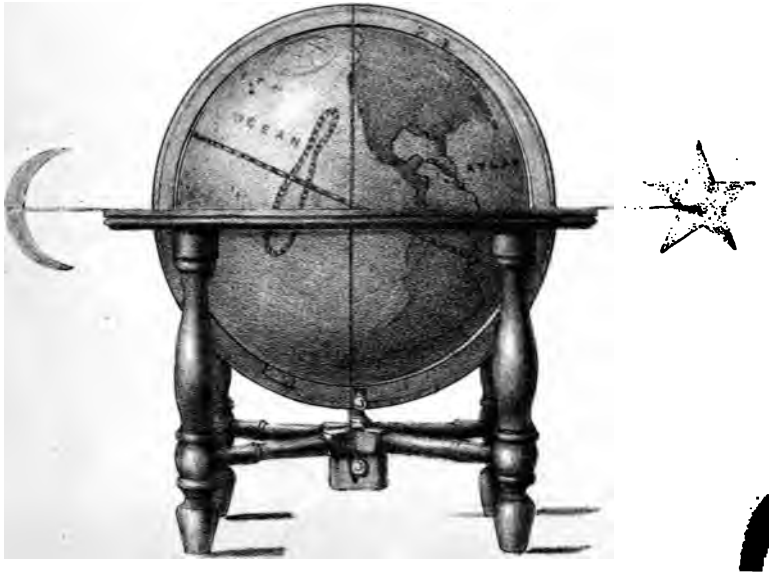


Fig. 8



It will be observed that there are two sets of these coast lines perpendicular to the plane of the ecliptic, or in a plane at an angle of 23° 28′ to the earth's axis, that is, one set is inclined one way and one the other, and which necessitates reversing the globe in Professor Owen's experiment. It is only necessary to call attention to the fact, and to observe how both sets coincide with the wire on one side of the globe or the other in this experiment, for it to be perceived that a rupture of the earth's crust on a great circle, and which the wire represents, would exhibit itself at an angle eastward of a meridian on one side of the globe and westward of a meridian on the other side of the globe, that is, when the earth, moon, and sun were in the respective directions indicated in the experiment.

If we look for the evidence of rupture in any great circle all round the earth, however, that is, if when finding a coast line corresponding to the wire on one side of the globe, we look for the coast line corresponding to the wire on the opposite side, we usually fail to find it. This is explained by the tetrahedral figure of the earth, because, having that figure, there will usually be a depression or ocean exactly opposite to where there is land. We must not look for antipodal coast lines; for if the ruptures or faults are there, they are hidden from view by the ocean.

I shall show also in the next chapter how these lines of rupture on great circles at right angles to the action of the internal tide wave are invariably cut off and shifted with the crust at the twin plane or dividing line of the two hemispheres.

It is a fact worthy of special note that no rupture of the earth's crust on a great circle at right angles to the plane of the attraction of the sun and moon can possibly occur in a plane at a larger angle to the axis of rotation than 28° or 29°, whatever may be the actual relative position of the earth, moon, and sun. At the equinoxes, the ruptures would be in a true north and south direction, and at any intermediate position between that and the solstices, the ruptures must be confined between a

meridian and a plane 29° from the earth's axis.* As a matter of fact, most of the grand lines of rupture on the earth's crust are either those we have mentioned, or they are north and south ruptures. Thus it would seem that they have all occurred either at the solstices or at the equinoxes, and when sun and moon have been in conjunction or opposition. The solstices† are the periods when the rupturing effect in one direction has the longest time to act, and when also there would be a greater number of conjunctions and oppositions, whilst the equinoxes are the periods when the great circle at right angles to the internal tide wave is coincident with the six grand north and south tetrahedral meridians, or edges of upheaval or depression, and therefore also a line of probable cleavage and easy fracture of the earth's crust. We cannot overlook, with the globe before us arranged as above, to notice the peculiarity of the approximately circular Arctic Ocean coast line, and how, by tipping the north pole 19° or 20°, or more nearly at right angles to the plane of the moon's orbit, instead of to 23° 28′, the Arctic shore lines coincide with the tangent lines formed by the wire, as the globe is revolved; whilst if we turn the south pole of the globe

* It will be remembered that the inclination of the plane of the moon's orbit to that of the sun being 5°, those rifts or faults which have been caused mainly by the lunar internal tide may appear in a plane 5°, on either side of 23° 28′ from the earth's axis of rotation.

† The sun remains a longer time nearly vertical to latitude 23° 28′ (north and south) than to any other latitude. There have occurred, therefore, more conjunctions and oppositions of sun and moon, when the sun is nearly vertical to 23° 28′, than when it is nearly vertical to any other latitude, that is, near the solstices. The sun remains nearly half the year vertical within 7° of either tropical line, whilst in the other half its verticality ranges over 32° of latitude. The rupturing effect of the internal tide wave may be greater at the solstices than at intermediate positions of the sun, because its effect at that time (when in conjunction or opposition to the moon) would be more directly opposed to the tetrahedral flattening. It is stated that the ocean tides are higher at the equinoxes than at the solstices. May not the counteracting effect of the rise of the flattened crust or ocean bottoms, in partial response to the internal tide wave, have its influence in reducing the ocean tide at the solstices? It seems to be an open question, however, as to how much, if any, the internal tide does affect the ocean tide at all times, and this, whether we suppose the earth to be fluid or solid, or at least like any solid we know anything about.

uppermost, and tip the pole 23° 28′ as before, Wilke's Antarctic coast line coincides with the wire. The tangent circle of so many great circle rifts, at an average angle of 23° 28′ to the earth's axis of rotation, would necessarily result in circular coast lines near the Arctic and Antarctic circles.

The question will occur, if so many of the main coast lines are to be referred to rupture and fault, the effect of the internal tide wave, what bearing has this fact upon the view that the continental outlines are modified contour lines or the water lines of an ocean surface level covering three fourths of a macled tetrahedral crust? The facts are not only not discordant, but the lines of rupture and fault may be brought as witnesses in favour of the tetrahedral hypothesis; for if we imagine the earth (supposed truly spheroidal) crossed by a series of faults at an angle to each other, thus forming pyramidal apices all over the globe, there is no reason why they should point south rather than north; they would point as often one way as the other, and divide the earth into a series of diamond-shaped islands, if the crust projected above the water level at all. The tetrahedral theory explains why the apices should point south, why there should be three continents mainly in the northern hemisphere, and one at the south pole, and why the faults, although on great circles, should not be visible in antipodal positions. Again, it is evident that the continental outlines, considered as ruptures at right angles to the plane of attraction of the sun and moon at the solstices, are at an angle not far removed from that which would be due to the water lines on a tetrahedral solid angle, so that the lines of fault and upheaval nearly coincident with the ocean contour lines would to a certain extent control them.

These grand coast lines, then, tangent to the Arctic and Antarctic circles, may be defined to be faults caused by the internal tide wave at the solstices, equinoxes, and syzygies upon a crust of which the grand reliefs and depressions are the result of its tetrahedral collapse, for fracture and fault alone will not explain the existence of our continents and depressed ocean beds. We require first the tetrahedral deformation of the spheroidal

crust, of which the interior is in a molten state, then the action of the internal tide, as well as tangential pressure, causing faults, fractures, and mountain chains, whilst the molten nucleus fills up every opening presented to it, keys up the crust, or overflows vast tracts on its surface; then comes denudation and erosion, oceanic and atmospheric (with their resulting deposits), which carve their own peculiar features out of the reliefs so produced. But no one cause, since the great tetrahedral collapse of the crust, resulting in four oceans and four continents, have more altered and modified the earth's surface configuration, the outlines of the land and sea masses, than the great lateral relative shift of the tetrahedral crust, between the northern and southern hemispheres, which we shall examine in the next chapter.

CHAPTER VI.

The great line or plane of lateral shift between the Northern and Southern Hemispheres of the earth's crust is on a small circle parallel to the plane of the ecliptic — Its cause.

On comparing in Chapters I. and II. some of the features exhibited on the earth's surface with the hypothetical model of the six-faced tetrahedron three fourths covered by water, we encountered some notable anomalies; we found that our three solid angles in the northern hemisphere, which should have appeared as regular three-lobed masses, like Fig. 1, were in each case divided, or nearly divided, into two by a transverse depression of sea. Europe—Africa by the Mediterranean, North and South America by the Gulf of Mexico and Caribbean Sea, and Asia—Australia by the seas of the Eastern Archipelago; and in the two last the southern portions seemed to be pushed eastward compared with the northern, or the northern portions were pushed westward compared with their southern prolongations; whilst the islands in these depressions presented a double curved line as if they were situated on the line of shift.

Arnold Guyot, in his first lecture on Comparative Physical Geography, already quoted, calls attention to the remarkable analogies of the three double worlds, or the three double continents, with "a water division" between the north and south portions of each. "The purest type," he says, "of this grouping of the continents is America; its two halves, North and South America, are nearly equal in size and similar in form; they form, so to speak, an equilibrium." . . . . "The other two double worlds are less regular, less symmetrical," although "the third double world, Asia—Australia, is more normal, it approaches nearer the type." . . . . "These views of Steffens," he observes, "even without being justified by a physical theory of the phenomena, are not the less of high interest, and lead us to consider

the grouping of the continents under a point of view of the application of which we shall by-and-by see the utility." It is the physical theory of these three double continents mainly that I propound in this and the preceding chapters.

Referring again to the globe just as we arranged it in the last chapter, with the axis inclined 23° 28′ from the perpendicular, and the sun and moon being supposed to be in the same positions as in that experiment, revolve it till the Gut of Gibraltar is brought under the brass meridian on the inclined side. Then from the centre of the Straits draw a circle round the globe exactly parallel with the wooden horizon, which, as before, represents the ecliptic, or plane of attraction, of the sun and approximately of the moon.

This small circle, thus drawn as it were by rule, forms the line of separation between the north and south portions of each of the three double continents, passing through the three dividing archipelagoes; and is in many respects the most remarkable circle (whether large or small) which can be traced upon our globe. It runs along the Mediterranean Sea and the north coast of Africa approximately parallel to it, and crossing the north part of Arabia, it runs down through the Persian Gulf, crosses the Arabian Sea parallel to the coast of Beloochistan and the north-west coast of Hindostan, traversing which, in the direction of its main valley, it comes out at a notch in the eastern coast, seeming to give that massive peninsula an ugly twist; then striking the Malay Peninsula at an elbow, just where it bends at an abrupt angle towards the same direction, it passes through the central parts of Borneo, Celebes, and New Guinea, preserving a closely approximate parallel line with the trend of Sumatra and Java and the Islands of the Eastern Archipelago, appearing to bend them with it; and passing through the middle of it for a distance of over three thousand miles, it emerges from it to cross nearly at right angles a shifted chain of islands with a north and south bend from an east and west trend; leaving the Queen Charlotte group and crossing the Pacific in close company with the Navigators', Marquesas, and other volcanic islands, it at length strikes North America a little to the southward of

the Isthmus and Gulf of Tehuantepec, one of the few practicable canal routes across the continent. Emerging at the Bay of Honduras, the line appears to draw the land of Yucatan and the west end of Cuba out of their normal trend and into line with it; then crossing Cuba and the Bahamas with the appearance of similar effects near the line of intersection it makes across the Atlantic, and leaving the volcanic group of the Azores a little northward, re-enters the Gut of Gibraltar.

Within ten degrees on either side of this line exist by far the larger number of the active volcanoes of the earth, and by pencilling it on Johnston's Chart, No. 10, of Volcanic and Earthquake Phenomena, it will be found to pursue its course through and amongst the volcanic and earthquake districts in an unmistakably marked manner.

If all these remarkable facts connected with this small circle or plane parallel to the plane of the ecliptic are sufficient to indicate that this *may be* a line of shift or twin plane between the crusts of the northern and southern hemispheres, is there any mechanical cause assignable that might produce such a separation and shift between the two crusts, and which will at the same time connect the facts with the tetrahedral modification of the earth's figure already pointed out?

There is no proposition more definitely settled in the mechanics of rotating bodies, than that a contracting rotating body increases, and a dilating rotating body decreases, the rate of its rotation. A fluid ellipsoid of revolution which is being modified tetrahedrally by the collapse of its cooling and solidifying crust in the mode in which the tetrahedral maps show our earth's crust has collapsed, becomes a body contracting its dimensions in middle latitudes in the southern hemisphere, and throwing up the crust in corresponding latitudes in the northern hemisphere. The three axes of depression (obtuse angles), or the centres of the three oceans, are in latitude 19° 28′ south, while the three acres of upheaval (acute angles), or the centres of the three continents, are in latitude 19° 28′ north. The remaining continent and ocean are at the South and North Poles respectively, and whilst they are themselves comparatively re-

moved from the effects of rotation, tend rather to increase the depression at the south, and the upheaval at the north in middle latitudes. The earth's crust * in its rotation moving from west to east, the necessary result has been that the upheaved floating crust in middle latitudes in the northern hemisphere, has had a tendency to be retarded, whilst the subsided floating crust in middle latitudes in the southern hemisphere has had its rotation accelerated, and to-day exhibits the two southern prolongations which reach farthest southward, South America and Australia, pushed well to the eastward.

Between the thin crusts of the two hemispheres floating on a molten nucleus—but the northern rising and the southern sinking, and therefore each tending to rotate at a different velocity—there may well be a line of rupture. The central line of separation appears along the small circle just traced. It is 12° north of the parallel plane dividing the earth into two halves, because the central line of the transverse tetrahedral upheaval (the transverse solid edges) is many degrees northward of the equator. It is in this plane because it is a plane parallel to the direction of the action of the internal tide wave, or parallel to the plane of the ecliptic, and at right angles to the plane of the great transverse rents, which we have seen in Chapter V., occurred also at the solstices, when the sun's action on the figure of the molten nucleus has the longest effect, and presents also more frequent opportunities for the sun and moon to unite in producing high internal tides, and which would, as well as causing ruptures in the crust at right angles, tend to produce rents, or at least cleavage in the direction parallel to its motion.

Plate III. shows a map of the world on Mercator's projection, or at least as much of it as can be conveniently delineated on

* I regret that I have been unable to see Mr. J. Evans' paper on the sliding of a solid shell over an internal fluid nucleus, published in the Royal Society's Proceedings for 1866, and which suggests a very probable cause for the appearances of a change of climate from ancient strata, which, when exhibiting tropical fauna or flora in Arctic regions, have probably travelled bodily northward along, or rather parallel to, the line of shift. I do not at present in the text enter into the question as to how far the crust of the earth in this movement slips over the nucleus or moves with it.

that projection, in which is indicated by an orange curved line the neighbourhood of the central line of lateral heave or shift between the two hemispheres, and the trends of the great coast line faults in a plane at an angle of 23° 28′ on either side of the earth's axis are also made conspicuous by red lines.

It will be observed that these latter lines never pass through the region where the shift has occurred, but the straight lines are cut off by the curved line. This looks as if the ruptures at right angles to the plane of the ecliptic had occurred before the shift, or at least that there has been a great deal of lateral heave since they were produced.

Bearing in mind that the figure of the solid crust of the earth is tetrahedral, this relative displacement of the crust in the northern and southern hemispheres seems analogous to the apparent twist of the two portions of a twin crystal.

By constructing a macled six-faced tetrahedron with the twin plane at the position and angle* of the assumed line of shift on the earth, and twisting the two twin portions about 15° in opposite directions, or 30° in the southern half to the right, or in the direction of the earth's rotation, we see before us at a glance the cause of the anomalous appearances on our earth, viewing it in the light of its tetrahedral figure; for by a slight movement round the twin axis (taking the three transverse acute angles for the three continents) we throw South America and Australia to the eastward of the northern portions of the solid angle that belongs to them; we raise Asia up out of the water at the same moment that we move it north-westward,† bearing in mind that

* It does not appear that what has been called the twin plane on the earth is parallel to the face of a crystalline form of the system, as the twin planes of crystals are always supposed to be. It is, however, not my object to identify the cause of the figure of the earth with crystallization, although there seems to be a strong analogy between the two, but it is to exhibit by the help of known crystalline forms the great facts, that the spheroidal earth-crust has flattened tetrahedrally, and that the crusts in the northern and southern hemispheres have been twisted and shifted relatively to each other.

† Mr. Henry V. Hind, in a communication to 'Nature,' 2nd July, 1874, calls attention to the supposed movement of the equatorial bulge, or Schubert's elliptic equator, and he shows how certain geological features in North America seem to require for their explanation "an easterly or westerly pro-

the centrifugal force of rotation heaps up the ocean towards the equator, we dip the west of Europe into the ocean, and at the same time cause three transverse depressions on the model at the positions corresponding to the Mediterranean, the Caribbean Sea, and the Eastern Archipelago, as well as another depression at the Persian Gulf, for it will be observed that the twin plane cuts the fourth acute solid edge on the model at this point. The heaping up of the ocean towards the equator by centrifugal force assists also in submerging the continental lands in the American and the Asiatic transverse depressions, for they are each in the torrid zone, whilst in the case of the latter, or Asiatic depression, the equator and the resulting highest ocean produces a number of continental islands, and entirely separates by sea the two halves of this continent, which in the other two are just connected by an isthmus.

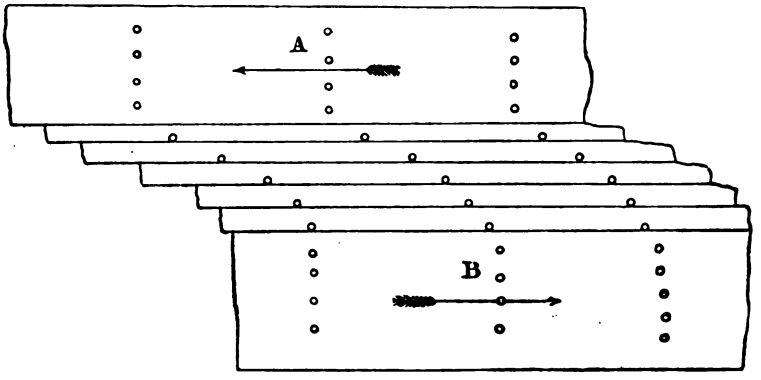
But there are many physiographical peculiarities on the earth which the model cannot show us, inasmuch as it is firm and unyielding, whilst the crust of the earth is a comparatively thin film, both flexible and frangible; it is capable of being ruptured and cleaved, as well as bent into flexures and contortions, and, more important than all, it is floating upon a fluid nucleus. The line, or plane of division, then, is not shown in one rigid line as in the twin plane of a crystal, but rather, as might be expected to occur, in a vast sheet of ice broken in two, whilst each piece is gradually forced in opposite directions. There is, however, at the same time a tendency for the broken edges to freeze together as they split in planes parallel to the direction of the forces.

Let A and B, Fig. 11, be two such sheets of ice. An inspec-

gress of elevation simultaneously with a northerly and southerly elevation, such as would be produced by the slow movement of an equatorial bulge in an east and west direction." The tetrahedral protuberances combined with the twin shift as here contemplated and accounted for may furnish an explanation of the appearances referred to by Mr. Hind, but inasmuch as they are probably also connected with elevation and subsidence from the alternate action of, and relief from, tangential pressure caused by the subsidence of the four sea bottoms, it is necessary to be cautious in defining the precise causes of each class of phenomena due to elevation, depression, or retreat of the ocean.

tion is enough to explain how the rows of stones or other objects on the ice representing elevations on the crust of the earth, and which had been originally in line, should be drawn into double curved lines, such as repeat themselves in the Caribbean Sea and Eastern Archipelago.*

Fig. 11.



A marked, but apparently anomalous fact in the earth's physiography, may perhaps be brought into relation with the phenomena of the twin plane. The highly volcanic peninsula of Alaska and the volcanic range of the Aleutian Islands extend about 1500 miles in the arc of a circle, which seems at first view to be related to or concentring with no other point or circle on the surface of the earth. By referring, however, to the globe, as arranged to observe the twin plane, the centre of this vast circle of igneous ejections is found to be the pole of the

* It is worthy of note in this comparison between the apparent twist between the two hemispheres of the earth's crust, that twin crystals exhibit phenomena analogous to these drawn out and curved lines, as shown by these Archipelagoes.

Ure's Dictionary, article "Diamond," remarks: "A good diamond should split readily in the direction of the cleavage; it sometimes happens, however, that the folia are curved, as in the case of twin crystals; when this happens the stone does not polish, and is therefore of inferior value."

Sir Henry James long ago remarked the "engine-turned" appearance of the lines on the earth's surface "analogous to loxodromic lines, or in curves such as would be produced if the poles travelled by a succession of movements along curved lines into their present positions."

axis of the twin plane, and the line itself is therefore parallel with the twin plane and with the plane of the ecliptic.

Although, as was observed in Chapter IV., the tetrahedral collapse has had no tendency to change the axis of the earth's rotation, but only to incline it, the twist of the crust on this twin plane must have done so, as it moves immense prominences northward and southward, and the magnetic pole may have some relation to this change in the axis of rotation, and to the generally twisted folia and skewed figure of the earth's crust, as suggested by Sir Henry James in a series of letters to the London 'Athenæum' in 1860.

The twin twist of the earth's crust has not necessarily been equal for the three continents. Whilst the great subsided bed of the South Pacific having thus its eastward rotation accelerated, has pushed South America far in that direction, notwithstanding the apparent protest of the stupendous upturned edges of the chain of the Cordilleras, which are a result of it, the African solid angle or continent having been divided by the twin plane far to the northward, where the tendency of its great elevated mass would be, on the principles just explained, to hang to the westward; it has maintained itself and its southern prolongation well together, and shows itself to-day as a massive continent, embryotic in figure and normal in position, and forming a fulcrum or point of resistance, as it were, against which the subsiding Pacific and Atlantic Ocean beds may act to upheave the giant Andes between them.

In considering this explanation of the earth's surface features by reference to the edges of a twin six-faced tetrahedron, supposed to be projected on to a circumscribing sphere, it is clear that some latitude must be allowed in the comparison. Still it seems as though Hopkin's crucial question with reference to Beaumont's pentagonal *réseau* may scarcely be answered in the negative when asked respecting the tetrahedral *réseau*, or Beaumont's *réseau triangulaire*. "Is the coincidence," he says in the Anniversary Address already quoted, "sufficiently near to justify the conclusion that the general phenomena of elevation are not only due to a physical cause perfectly general

as regards the whole of the earth's surface, but also such that the pentagonal"—tetrahedral—"*rêseau* shall be the accurate geometrical type of the resulting phenomena?"

But after all, even if it be not strictly accurate, and there have been many causes shown for irregularities, yet if the employment of the *réseau triangulaire* has enabled us to detect an important and nearly symmetrical deformation of the normal spheroid, as well as a vast system of relative shift in the crusts of the two hemispheres of the earth, one of the great objects of Beaumont's labours will have been accomplished, and the discovery would be a result of his method commensurate with the genius which devised it.

CHAPTER VII.

Geodetic operations and general theories of the earth's figure have not, so far, exhibited the tetrahedral flattening of the spheroid, and why.

THERE are some evident reasons why the measurements of arcs, conducted with so much care by different nations, should not have thus far exhibited the fact that the spheroidal crust of the earth is flattened at four equidistant points on its surface, the most apparent being that no measurements have been taken over the central portions of the four great oceans, where this effect is mainly to be looked for. Again, the ellipsoidal curves that have been deduced from the measurements of degrees of longitude on continental areas are all referred to the ocean level, which tends to preserve, by the earth's rotation, a figure more truly spheroidal than that of the solid crust, the form of which, however, it is of the most importance to ascertain.

The figure of the earth, as deduced from pendulum experiments, is open to similar objection; indeed the so-called remarkable result obtained from them, that the density of the earth's crust increases over the ocean, is perhaps best explained by the depression or flattening of the earth's crust in that direction, for this would produce the same effect on the pendulum or the torsion balance.

Pendulum experiments on islands, some distance at sea, often show greater attraction* than on continents, whereas they should, according to the spheroidal theory of the ocean surface, show less, on account of the substitution of water for the denser land. Archdeacon Pratt, in his treatise on the 'Figure of the Earth' (section 192), accounts for this increased attraction by supposing that the ocean beds are generally of greater density than continental strata, the result, as he considers, of the greater

* Pratt Soc., 142.

contraction which produced them; and there appears, indeed, to be often a real deflection of the plumb-line towards the sea, as the Archdeacon points out in seven coast stations out of thirteen in India. But upon the hypothesis of a thin collapsed crust, and no greater contraction whatever of the solid strata under the sea than on the land, there appears an evident cause for the greater density of the molten interior beneath the collapsed portions of it, namely, that the fluid is under a higher head, and therefore more compressed.

The four great protuberances or acute angles of the solid crust of the earth, the prominences under the ocean as well as above it, must have an important effect in raising the ocean level towards them, and of flattening it over the great depressions of the ocean beds. This tetrahedral flattening will not be fully shown by the pendulum on account of the enormous deficiency of land, and the depth of the ocean may not be the full measure of that deficiency by reason of the flattening of the surface.

The elliptic equator, as deduced by General de Schubert, the reality of which Pratt, having faith in the truly spheroidal form of the earth, denies (section 176), seems to be probably a partial discovery of the facts of the tetrahedral collapse and twin shift. It is referred to here mainly as exhibiting the unsatisfactory state of our knowledge of the actual figure of the earth, although Major Clarke makes the longest meridian between 13° and 41° east, which so far agrees well with the tetrahedral maps. Fig. 5 exhibits the general form of the earth's solid surface at the equator, as deduced from the position of land and sea and the assumed tetrahedral collapse; indeed that figure seems to represent generally an exaggerated outline of the earth's section, taken through the plane of any parallel of latitude whatever, and it seems a rather hasty deduction to assume a regular elliptic equator from the results of a few local measurements. When once the earth was found to be not a spheroid, a new and thorough system of measurement became necessary to ascertain its precise figure, although the tetrahedral maps may exhibit generally the four poles of depression and the four poles of relief.

The calculation of the amount of the precession of the equinoxes due to a certain ellipticity of the earth's figure, and which is found to agree fairly with the calculated ellipticity from measurement, has really no bearing on the tetrahedral flattening of the spheroid, for it is a symmetrical flattening, which, whilst changing the earth's figure, causes it to tilt into a position of repose, and, as explained in Chapter IV., first places the equatorial bulge in a position to be acted upon by the attraction of the sun and moon. The tetrahedral modification of the earth's figure is neutral, or nearly so, with respect to the forces acting in precession and nutation, because it has been brought into a position of equilibrium by those very attractions, leaving them to act upon the equatorial protuberance as if the tetrahedral flattening did not exist.

What has been called another independent proof of a definite ellipsoidal figure of the earth, namely, the moon's position in latitude, is merely the converse of the last proposition.

The fluid theory of the earth's figure proves nothing, but is probably a close approximation to the true figure, except as modified by the tetrahedral collapse and the twin shift, forming a combination of the spheroid of revolution with the twin six-faced tetrahedron, and so combined and poised that each figure may be independently affected by attractions or independently shown to exist without detecting the other.

It would be easy to select from the literature of geodesy a large amount of evidence of the unsatisfactory results of the estimates of the earth's figure which have been at different times deduced from the measurements. It will suffice to present two quotations which, while admitting the uncertainty of the results, foreshadows the earth's tetrahedral modification of figure. Laplace, in the work already quoted, p. 121, says, "There is every reason to believe that it (the earth) is not a solid of revolution, and that its two hemispheres are not equal on each side of the equator."

A writer in the 'English Cyclopædia' (1861), art. "Geodesy," says of the various geodetical expeditions, "They have served at the same time to demonstrate that the earth is not a spheroid,

that it is not a solid of revolution, and that the figures of the northern and southern hemispheres are dissimilar."

It may be that the carefully conducted experiments of the Astronomer Royal, in the Harton Pitt Colliery, in 1855 (?), failed to yield the mean density of the earth which other experiments lead us to believe is nearly the true one, because the figure of the earth is not a simple spheroid of revolution as assumed in that experiment, but a spheroid tetrahedrally flattened, involving an entirely different determination of the mean level of the earth's surface, whilst the sea level, which was taken to be the mean level, would be comparatively useless as its indicator. The Astronomer Royal, instead of comparing the vibrations of the pendulum at the surface of the earth and at 1600 feet beneath it, may have been above or below the true mean surface in both situations.

The extent of the tetrahedral flattening of the spheroid will have to be ascertained by much more extensive experiments and measurements than any yet attempted. Indeed Pratt (section 211) admits that geodesy has taken no account of such flattenings as are here contemplated, neither would "a geodetic measurement of one meridian from pole to pole," which he there suggests, give us the figure of the earth. At least three great circles of longitude should be measured, or as nearly so as practicable; whilst the Arctic and Antarctic regions will have to be more fully explored. Parallels of latitude should also be measured, more especially towards the central parts of the great oceans. The French astronomers at Tahiti long ago considered that they had detected a remarkable flattening in that part of the South Pacific.* The pole of that obtuse angle or area of depression is shown by the Map No. 1, Plate II., to be within a short distance of Tahiti. It is evident that the ocean surface level would follow to some extent the great tetrahedral depression of the solid crust under them, or the ocean beds, and heap up towards the continents, and, judging from the apparent relative mean levels of the bottoms of the four great oceans and of the four great continental areas, the tetrahedral collapse of the earth's solid

* I regret that I am unable to refer to my authority for this statement.

crust may be of the same order of effects as that of the equatorial protuberance itself. The depression or flattening of the central ocean surfaces, even to say nothing of the beds, particularly of the Pacific, may be to an extent entirely unanticipated.*

If there be any truth in these views of the figure of the earth and the cause of it, Archdeacon Pratt's hypothesis of radial contraction of the solid earth (section 192) in certain directions, and the greater density of ocean beds in consequence of that contraction, cannot be also true, although it seems to have been very generally accepted. Indeed it may be asked, why should the earth contract more in one direction than in another, and why more especially should it as a rule contract most on one side, precisely opposite to where it has contracted least on the other; as the tetrahedral maps clearly show it has, if at all? On the hypothesis, however, of a tetrahedral collapse of the crust, as explained in Chapter III., the facts are intelligible. It is surely a misapprehension arising from the Archdeacon's confidence in the simply spheroidal form of the earth and ocean surface, when he assumes, in the work already quoted (section 215), "that the solid parts of the earth's crust beneath the Pacific Ocean must be denser than in corresponding parts on the opposite side, otherwise the ocean would flow away to the other parts of the earth." If the surface of the Pacific Ocean were known to be truly spheroidal, it would require a

* Amongst the subsidiary effects of this deformation of the spheroid, may perhaps be reckoned the constant low barometer in the southern parts of the South Pacific Ocean—an abnormal instance of it—as ascertained by Ross and other navigators. The immense hemisphere of ocean raises us when at its surface above the mean level of earth and sea together. The vast mass of water of the specific gravity of 1·03 only takes the place of rock of the specific gravity of perhaps 3, and virtually raises us higher into the atmospheric ocean which is attracted by it, or rather the curve of the atmospheric surface is lowered by having immediately beneath it a deep stratum of small density and enormous area. The remarkable circumstance also of the barometer being often found to fall steadily and invariably instead of rise, as travellers (see Lieut. Maury, in a communication to 'Silliman's Journal,' 1855 or 1866) descend the slight slope from the base of mountain ranges towards the sea coast, is probably caused by the absence of matter near the sea and the heaping up of the air or the raising of its curve of level over the mountain range by the attraction of its mass.

violent hypothesis of this kind to keep it so, but if it is flattened as the Frenchmen said they found it, it has partially followed the depression of its bed, till it becomes a surface of equilibrium. The assumption of Pratt, however, with regard to the spheroidal form of the surface of the ocean is the one which vitiates all deductions from measurements of degrees, as to the true figure of the earth, for all the estimates from them are based upon the assumption that the sea level is part of a true spheroid, which it probably is not, and would not represent the figure of the solid crust if it were. It is acknowledged, indeed, by most writers on geodesy that this, the very basis of the science as heretofore practised, the assumption of a true spheroidal figure for earth and sea, is a *petitio principii* without which every calculation from the measurement of arcs, deducing a certain ellipse, as applicable to the figure of the whole earth, falls to the ground.*

Outside then of unwarranted assumptions, the tetrahedral maps show by inspection that the admittedly spheroidal figure of the earth, even when referred to the sea level, *must* be tetrahedrally modified, and the solid crust itself much more so.† It is the figure of the solid crust of the earth which we have been in search of in these chapters, and which figure geodetic operations have hardly contemplated, and which, as we have seen, the astronomical and fluid theories usually employed, although true, do not detect, whilst, on the other hand, the angle of the inclination of the earth's axis of rotation to the plane of its orbit, whether viewed in connection with Laplace's nebular hypothesis or not, closely agrees with the tetrahedral flattening of the spheroid, which I endeavour to show as a matter of fact exists.

* Archdeacon Pratt refers to this point in the following terms (section 167): "We would observe that the making the axes of three arcs equal to each other amounts to assuming that the mean form of the earth is an ellipsoid of revolution, an assumption which has been made by every other investigation in this subject."

† It should be further borne in mind that the equatorial swell of the ocean from centrifugal force, as well as the attraction of three poles of relief in the northern hemisphere against one in the southern, hides to a large extent the three tetrahedral acute solid angles in the northern hemisphere; and on the two intertropical depressions caused by the twin shift, partially submerges them, leaving only islands, shallows, and an isthmus, to show where they are.

CHAPTER VIII.

The tetrahedral collapse and shift of the earth's crust a matter of observation and deduction from the consideration of the great surface-features of the earth, and is probably now in progress—Conclusion.

It seems interestingly corroborative of this view of the earth-crust's tetrahedral collapse, that some of our most thorough and observant geologists call attention to the recent vast subsidence of the ocean beds, and the rise of the continents in mass. Darwin's beautiful Atoll-island theory first raised the curtain and exhibited the great Pacific Ocean bed in the act, geologically speaking, of subsiding. Dana, in the last chapter of his work on 'Corals and Coral Islands,' reviews these phenomena of subsidence, and applies them to the three great oceans, the Atlantic, Pacific, and Indian, showing that the central portions of their beds are probably regions of recent or actual subsidence; and it only requires us to be able to apply the same law to the fourth remaining ocean, the unknown Arctic, for the whole tetrahedral collapse to be seen in progress.

Mr. Howorth, in several recent articles in 'Nature,' calls attention to the evidences of great regions of actual upheaval and subsidence, and infers that all the continents are upon the whole rising,* and the ocean bottoms sinking; and Dana, in the chapter already referred to, connects oceanic subsidence with continental upheaval; indeed, if the four great ocean beds are simultaneously subsiding, the continental protuberances (including those portions just *beneath* the sea) must be thrown more into relief as a necessary result, and the water at the same time drained from them, as the ocean basins increase their capacity.

* Mr. Howorth's evidences of the actual rise of northern lands may be accompanied by, and be partly the result of, a subsidence of the sea-bottom at and about the North Pole, although the tetrahedral collapse theory contemplates occasional partial re-elevations of the collapsed areas.

If we imagine this relative subsidence and upheaval at eight antipodal points (see Maps) to have been accomplished, as it most probably would be, by oscillatory or reactionary movements,* which were necessarily, as the earth contracted, larger upon the whole in a downward direction on the oceanic or subsiding areas, the great recognized geological phenomena become intelligible, for as seems to be indicated by them, the continents would always have been continents, and the oceans, oceans. Whilst the central portions of the oceans yield no speck of the old sedimentary or rather continental land-derived strata, the continents show that they have emerged from the ocean with repeated partial re-submergences, and the sedimentary strata are deposited successively on the flanks and in the hollows of the continental swells and ridges, except where the evidences of tangential pressure, a necessary result of the subsidence of the four ocean beds, are seen in mountain ranges of recent deposits thrown up at right angles to a line drawn from towards these ocean centres, as a glance at the tetrahedral maps will exhibit, the larger ridges being found opposite the larger oceans. Thus the tetrahedral deformation of the spheroid exhibited in four oceanic depressions resulting in four antipoidal continents corresponding to the acute crystalline angles and edges, as well as some of the more prominent mountain ranges upon them, and the displacement of southern lands, are seen to be the effect of the same collapse,† and are mutually corroborative of it.

* A simple *subsidence* of the four sides of a tetrahedroid as here contemplated might exhibit appearances of *upheaval* or submergence along the borders; one movement may produce opposite effects on the coast-line depending upon what part of the slope the water-line was, or whether each coast was subsiding more or less rapidly than the ocean waters were retreating to their deepening beds.

† Captain C. E. Dutton, U. S. A., in an article published in the 'American Journal of Science and Arts' for August, 1874, on the contractional hypothesis, and in which he takes the ground opposed to contraction and collapse, makes the following significant remark (page 122): "The case in question is not that of the cylindric arch, but nearly that of the dome; and if a collapse is to occur, every terrestrial great circle must contract equally and simultaneously, *otherwise great deformations of the earth's normal figure would result.*" Again (p. 123): "It is here that the analogy of the withered apple fails. If it is corrugated irregularly by shrinkage, it fails to preserve its original figure; and conversely,

This intimate tetrahedral connection between the ocean beds and the continents is further illustrated by what Page* has called "the four great oceanic river systems, the Arctic, the Atlantic, the Pacific, and Indian," else, as Mr. Ruskin has asked, "Why should rivers always run to the sea?" The tetrahedral hypothesis answers, because the continents on which the rivers exist are in the main merely the reliefs of which the ocean beds are the depressions and the cause; they are the upper portions of the same slope as the subsided sea-bottoms, modified, however, by the ridges raised on them by the tangential pressure induced by that subsidence, and by the ruptures at right angles to the internal tide waves, and, as if to make up for our want of knowledge of the central parts of the Arctic Ocean, the map of this basin (this obtuse tetrahedral solid angle) exhibits in a singularly distinct manner the mode in which the rivers run from the circumference towards the central polar depression.†

The marked manner in which so large a number of the rivers of the world, which do not run into the Arctic Basin, trend southward, is a striking evidence of the general incline of the earth's surface in that direction, from the transverse acute edges at least of the six-faced tetrahedron to where the lands terminate in the ocean.‡ When to this fact is added that those lands show themselves ending in three main and several minor

if it preserves its original figure it must be corrugated uniformly." It has been the object of these pages to point out the great but regular deformation which *has* resulted from the collapse of the earth's crust.

* 'Physical Geography,' by David Page, F.R.S.E., F.G.S. Edin. London. 1863. Page 114.

† The circular coast-line of the Arctic Ocean seems, notwithstanding as if it might be the result of faults (and the two facts are compatible), formed near the tangent-lines of all the lines of rupture, running at right angles to the plane of the attraction of the moon, as explained in Chapter V.

‡ The Nile, which flows northward, has its source between the raised ridges formed on an area of general subsidence towards the south by that very subsidence, that is, of the sea-bottoms on each side of them, and it runs into the Mediterranean depression caused by the twin shift. In the same manner the ridges of Brazil, formed by the subsidence of the bed of the Atlantic, deflect the Amazonian system of rivers towards the Caribbean depression caused by the twin shift.

apices pointing southward, another necessary effect of the incline in that direction, the tetrahedral depression (or subsidence?) seems demonstrated, if we believe in the existence at the same time of an Antarctic Continent and an Arctic Ocean.

The relative shift between the crusts of the two hemispheres is not only deducibly from the observed facts, but must, if the great southern subsidence be admitted, be a result of it, so long as the nucleus remained fluid and the crust thin; and if that is the condition of the earth to-day, as I believe it is, and the ocean beds are still upon the whole subsiding from contraction of the molten interior, the crust of the southern hemisphere must be creeping eastward relatively to the northern hemisphere, and many centuries may not elapse before carefully compared determinations of longitude may detect the movement.

Many efforts have been made to connect the facts of mountain making and volcanic action, of the oceanic depressions and continental reliefs, and of their movements of oscillation, and to find some prime mover which may serve for all. The compound figure of the earth, and contraction and collapse the cause of it, as propounded in the preceding pages, seems to open a way to the solution of these problems; but until our views of the nature of volcanic action and of the earth's interior become more fixed and true, we shall continue to flounder in hopeless difficulties.

In Part II. of this inquiry into the 'Vestiges of the Molten Globe' I propose to consider these questions, with the assistance of some observation of the great active volcanoes and the great extinct volcanic range of the Hawaiian group, and will merely say in the meantime that I am forced by these observations to take a different view of the nature of volcanic action and of the earth's crust and interior to that which has recently prevailed, in England more especially.* In the Third and last Part, under

* I allude more particularly to the commonly received opinion that water or the access of water to the heated nucleus is necessary to volcanic action or lava eruptions, and to the theory of a solid earth or a thick crust, which the facts and views now presented seem also to contradict.

the head of Physiography,* I shall endeavour to connect, more in detail, the earth's surface features with volcanic action and the tetrahedral collapse and shift of a thin crust upon the molten spheroidal nucleus, the broader and more salient features of which have here been sketched out.

The earth's physiography, as exhibited in a map or globe, as well the great pyramidal apices pointing south, the continents, the oceans, the coast lines, and the flow of the rivers, as the form and position of the islands, and the smaller configurations of land, constitute a great picture-puzzle, the pieces of which have been disarranged by the movements affecting them, but which only require patience and the clue to trace back to their simple and symmetrical origin; for, as we have seen, the forces at work seem to be analogous to those of crystallization,† the laws

* It may be remarked here that works and maps on Physical Geography, in the branch at least of Physiography, are often a running comment on the tetrahedral collapse of the earth's crust and its various effects, but without recognizing it. I allude more particularly to Guyot, Dana, Page, and Professor Nichol, in A. K. Johnston's Physical Atlas. The latter comprises very succinctly the ideas upon which they all find material to dilate, thus (page 4): "If regarded from a very general point of view, and if Africa be connected with Europe, and Australia with Asia, our existing continents may be said to be made up of *three masses, of the form of the Americas*" . . . . "pointing rather to some general though obscure cause of the figure of the solid on which the present continents are placed, and the mode of action or habitual direction of the forces existing within the interior of the globe." It will be observed by reference to the tetrahedral maps that the *fourth* continental but *undivided* mass, the Antarctic continent, and which is not referred to by Professor Nichol, completes the four acute angles of the crystal.

The great N.E. and S.W. and N.W. and S.E. trends of volcanic islands might perhaps have been referred to as one of the more prominent features of the earth's surface illustrative of this theory, being parallel to the transverse crystalline edges of the six-faced tetrahedron. Reference might also have been made to the explanation the theory gives of Beaumont's parallel and contemporaneous mountain chains, and of those which are contemporaneous but not parallel, or parallel but not contemporaneous. But these subjects lead us into details which may perhaps be more advantageously considered separately from the broader facts, illustrative of the figure of the earth and the cause of it.

† It may be that whilst the phenomena of crystallization throw light upon the earth's form and the cause of it, the study of so large a crystal as our planet may reflect some rays upon the operation of that mysterious force.

of which are definite and exact in producing certain regular figures, and which, however confused and complicated in the result under particular circumstances, are always decomposable into their primary forms.

Thus the study of the origin of the earth's figure and surface features, or tellurics, may well become a distinct branch of science, which should lead to the solution of some of the most interesting problems which arise from the contemplation of those phenomena, as well as of the cosmical relations which seem to mechanically connect both with the molten interior of our planet —that interior which writers on dynamical geology often treat as a sealed book, either prohibiting all speculation on the one hand, or as not contradicting the wildest guesses on the other. But since the startling revelations of the spectroscope respecting the constitution of the sun and stars, we may surely hope for better things. Indeed who can doubt that a persistent course of experiment and analysis, of trial and error perhaps, will ere long reveal a mental spectrum of the nature and condition of the white hot interior of the earth, hardly less reliable than the more physically brilliant indications of the nature and condition of the matter in the suns of remote systems. In that mental spectrum the tetrahedral collapse and twin shift of the crust, visible in the earth's surface features, and in the inclination of the axis of rotation, may form lines hardly second in value to the spheroidal figure, for while they all point to an originally fluid globe, if the tetrahedral collapse and shift be still in action, it indicates a still fluid nucleus and a thin crust.

END OF PART I.

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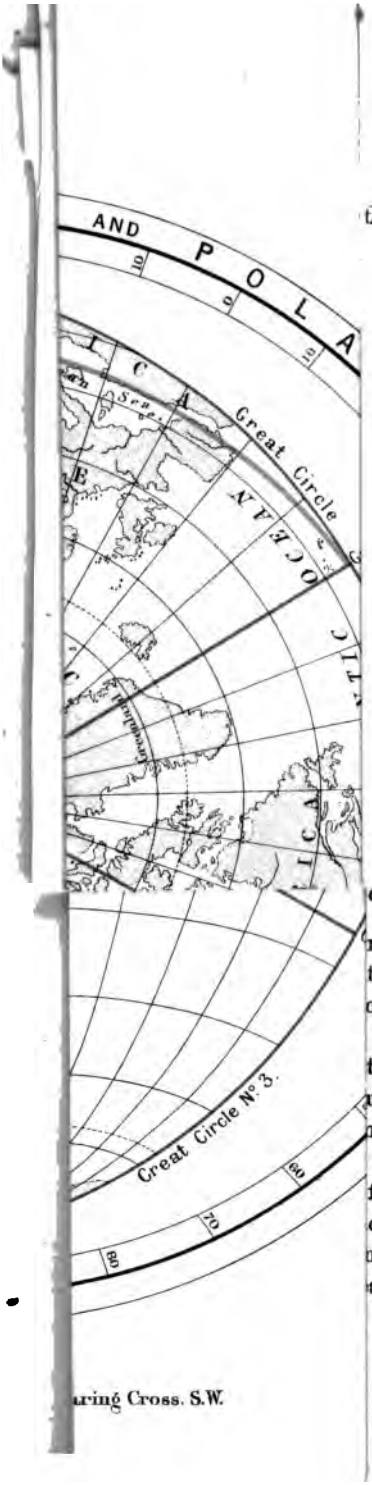
the Molten Globe" Plate II.



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Green's "Vestiges of the Molten Globe" Plate III.